PRESSURE DISTRIBUTION ON HELICOPTER FUSELAGE

Anas Faiz Aris, Iskandar Shah Ishak*, Airi Ali, Norazila Othman

School of Mechanical Engineering, Faculty of Engineering
Universiti Teknologi Malaysia
81310 UTM Johor Bahru
Johor, Malaysia

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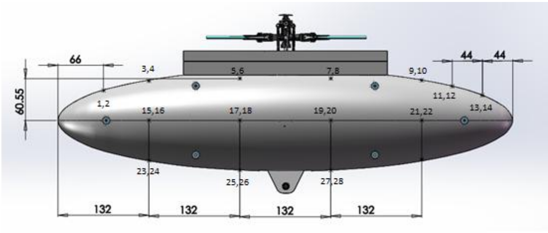
*Corresponding author
shah@utm.my

GRAPHICAL ABSTRACT



KEYWORDS

Advance ratio; helicopter fuselage; pressure characterisation; rotorcraft; wind tunnel;

ABSTRACT

Modern rotorcrafts are subjected to some of the most complex flow behaviors ever encountered by the rotorcraft aerodynamicist. The objective of this research work is to investigate the pressure distribution on a helicopter fuselage in relation to the helicopter phenomenon. In this experimental work, a standard ellipsoidal helicopter fuselage model was mated to a main-rotor-hub assembly from a remote-control helicopter. The model was equipped with 28 pressure taps where the locations of the taps were predetermined by CFD analysis. The experiments were carried out in the UTM wind tunnel with a test section of 2m (width) x 1.5m (height) x 5.8m (length) with the maximum wind speed of 80 m/s. Data of pressure corresponding to the variations of helicopter's pylon configurations and advance ratios were recorded using Electronic Pressure Scanning System. The effects of advance ratio and pylon configuration to the pressure distribution on helicopter fuselage were analysed. Findings reveal that the employment of pylon does augmenting the pressure coefficient on the rear part of the fuselage. Results also indicate the pressure distributions on the right and left sides of the fuselage are unsymmetrical indicating a very complex flow phenomenon experienced by the helicopter fuselage.

INTRODUCTION

This research aims to investigate the pressure distribution on helicopter fuselage in relation to the helicopter tail shake phenomenon. Helicopter tail shake phenomenon is generally can be addressed as a tail shake problem due to the highly unsteady helicopter wake that hit the tail part of helicopter during its forward flight. This phenomenon has been identified to be an interaction of a turbulent wake with the tail part of the structure [1]. Essentially, it occurs as a consequence of interaction between the main-rotor-hub assembly wake and the vertical tail of the helicopter [2]. It had being reported on the AH-64D Longbow Apache helicopter, the vibration resulted in increased cockpit lateral vibration levels, which increased crew workload and reduced their ability to perform precision tasks [3].

Experimental aerodynamic investigations remain the subject of interest in rotorcraft community since the flow around the helicopter is highly unsteady [4]. According to Wang Qing and Qijun Zhao [5], the helicopter rotor blades work at higher unsteady aerodynamic environment compared to the fixed wing aircraft, making its aerodynamic characteristics are more complex. General complexity of modern, compact helicopter design, associated with scaling difficulties, are contributing factors towards limited success in predicting Interactional Aerodynamic (I/A) related vibration problems [1].

In this research, focus will be on main-rotor-hub assembly's wake as it is believed to be the major contributor of the problem. This allows the tail shake investigation to be conducted using blade stubs configuration [6,7,8]. Blade-stubs configuration is a combination of main-rotor-hub assembly with shorter blades.

METHODOLOGY

The selected model for this wind tunnel test campaign is a standard ellipsoidal fuselage with the axes ratio of longitudinal to lateral axes is 4.485 [9]. The experiment was conducted at UTM-LST, Aerolab UTM. To investigate the effect of pylon, the fuselage was mated to two types of pylon which were ellipsoidal pylon and rectangular pylon.

To determine the pressure distribution around the helicopter fuselage, the model was equipped with 28 pressure taps, predetermined by CFD analysis. Each side of fuselage is embedded 14 pressure taps. The drilling of taps were made perpendicular to the surface as the flow around the model is tangent to the surface. Figure 1 shows the locations of pressure taps on the model.

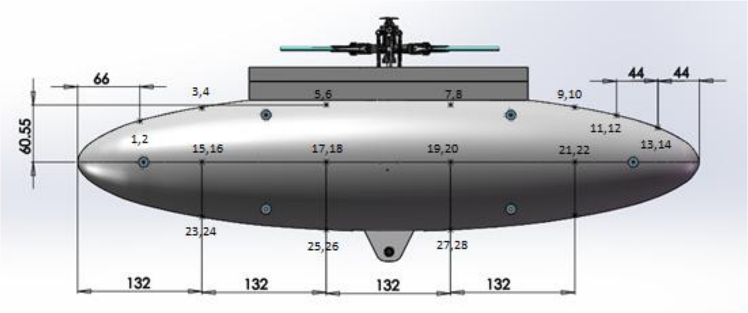


Figure 1: Taps location on the model

According to Ishak, the most severe wake happened when the helicopter was nosed down to -5º [3]. Hence in this experiment, the model was nosed down to -5º. Figure 2 shows the setup of model, equipped with the pressure tubes in the wind tunnel.

Figure 2: Model setup in wind tunnel from left without pylon, ellipsoidal pylon and rectangular pylon

Testing Parameters: The testing parameters are shown in Table 1.

Table 1: Testing Parameters

Helicopter Fuselage with Different Pylon Configuration	Angle of Attack	Rotation of Main Rotor Hub (RPM)	Wind Speed (m/s)
Fuselage without pylon	-5°	0, 1200, 1400 and 1600	20 and 30
Fuselage with ellipsoidal pylon	-5°	0, 1200, 1400 and 1600	20 and 30
Fuselage with rectangular pylon	-5°	0, 1200, 1400 and 1600	20 and 30

RESULTS AND DISCUSSION

Effect of Rotation of Main Rotor Hub on Pressure Distribution around Pylon and Rear Fuselage

Figure 3 to Figure 8 shows the graph of pressure coefficient, Cp against rotation of main- rotor-hub.

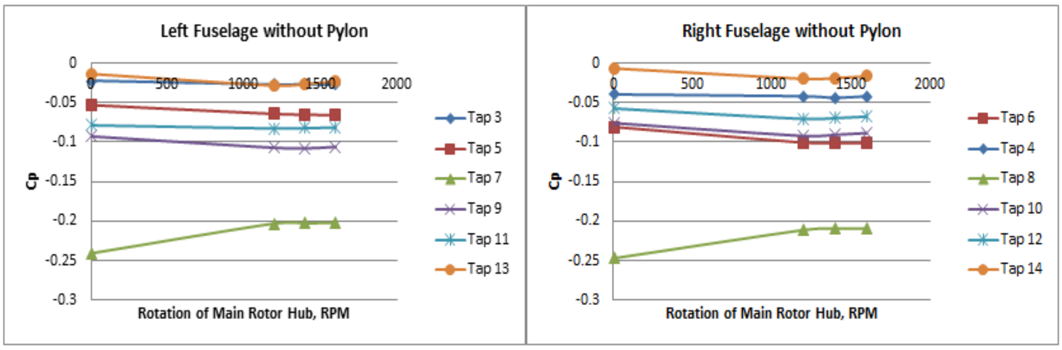


Figure 3: Graph of *Cp* against main-rotor- hub rotation for fuselage without pylon at 20 m/s speed

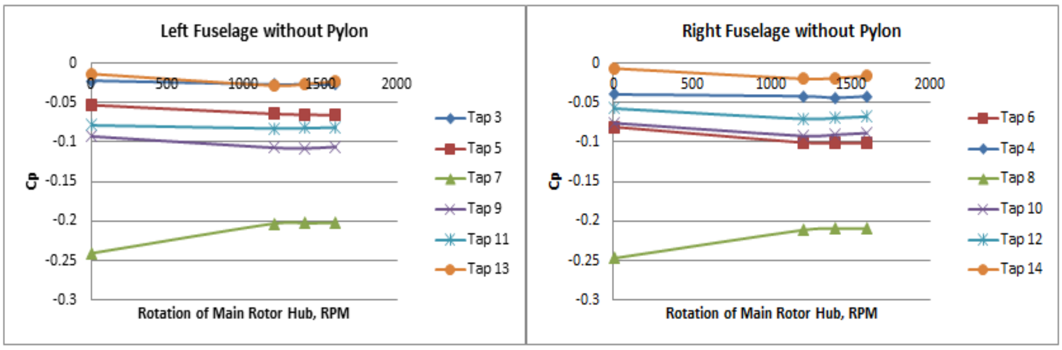


Figure 4: Graph of *Cp* against main-rotor- hub rotation for fuselage with ellipsoidal pylon at 20 m/s speed

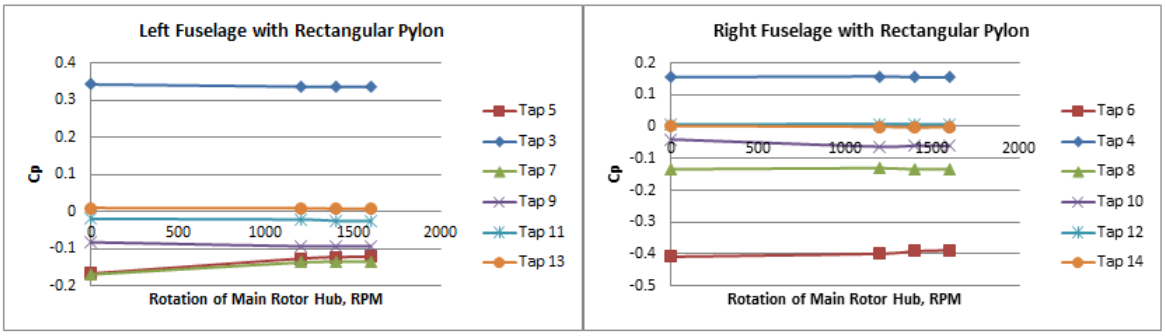


Figure 5: Graph of *Cp* against main-rotor- hub rotation for fuselage with rectangular pylon at 20 m/s speed

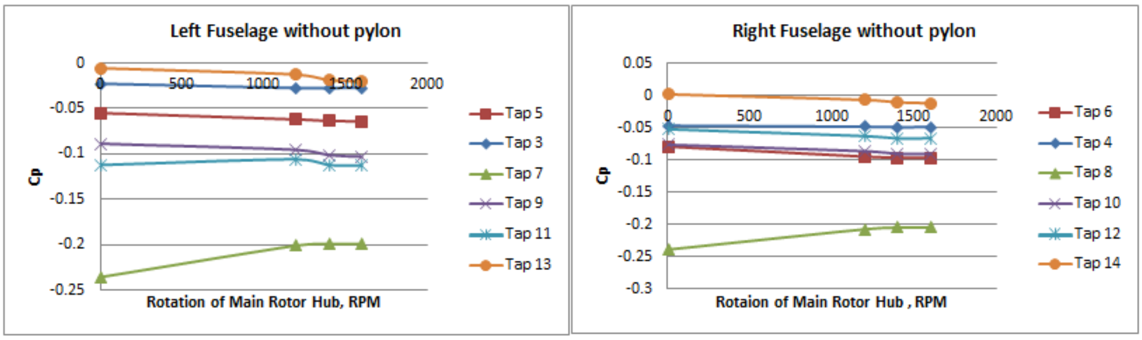


Figure 6: Graph of *Cp* against main-rotor- hub rotation for fuselage without pylon at 30 m/s speed

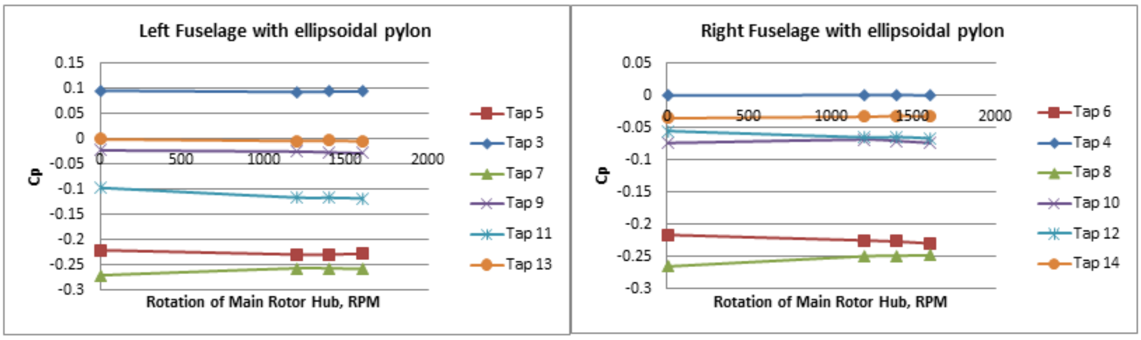


Figure 7: Graph of *Cp* against main-rotor- hub rotation for fuselage with ellipsoidal pylon at 30 m/s speed

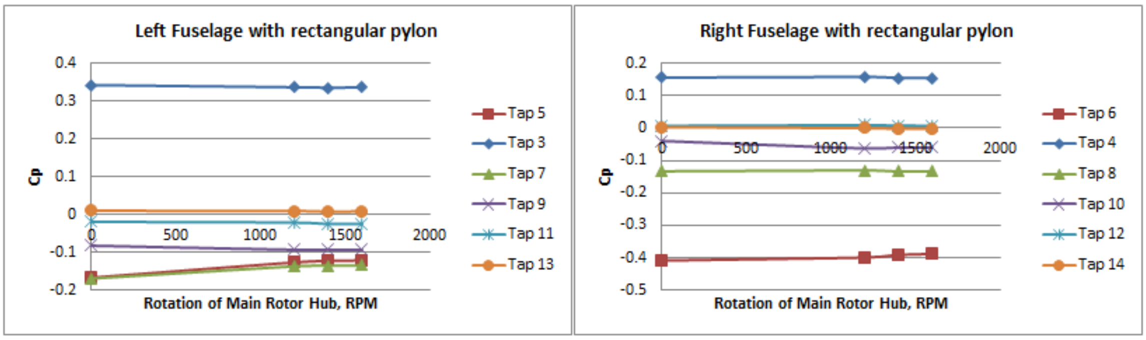


Figure 8: Graph of *Cp* against main-rotor- hub rotation for fuselage with rectangular pylon at 30 m/s speed

Figure 3 to Figure 8 show that for pressure in front of the pylon, represented by Tap 3 and Tap 4, is quite independent to the RPM. Contrarily to the side of pylon, represented by Tap 5 and Tap 6, the pressure distribution is obviously affected by the RPM in which the pressure decreases for fuselage without pylon and ellipsoidal pylon configurations, but increases for rectangular pylon configuration with respect to the RPM. For Tap 7 and Tap 8, the pressure for fuselage without pylon and ellipsoidal pylon decreases as the rotation of main rotor hub increases. Meanwhile for rectangular pylon configuration, the pressure increases for the left side of fuselage but decreases for right side of fuselage as rotation of rotor hub increases. The distribution of pressure is also noted unsymmetrical, thus indicating very complex flow phenomena in this region.

EFFECT OF PYLON CONFIGURATION ON PRESSURE AT UPPER SURFACE FUSELAGE

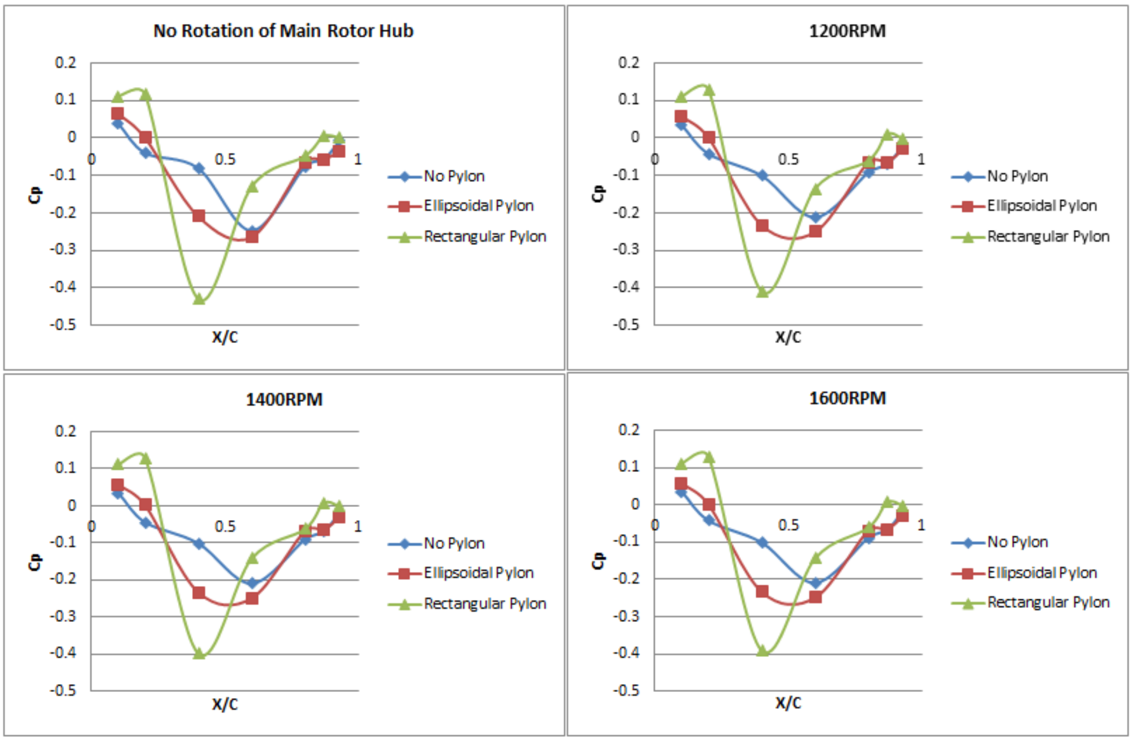


Figure10: Graph of *Cp* against x/c for right fuselage with different configuration of pylon at different rotation of main rotor hub at 20 m/s speed

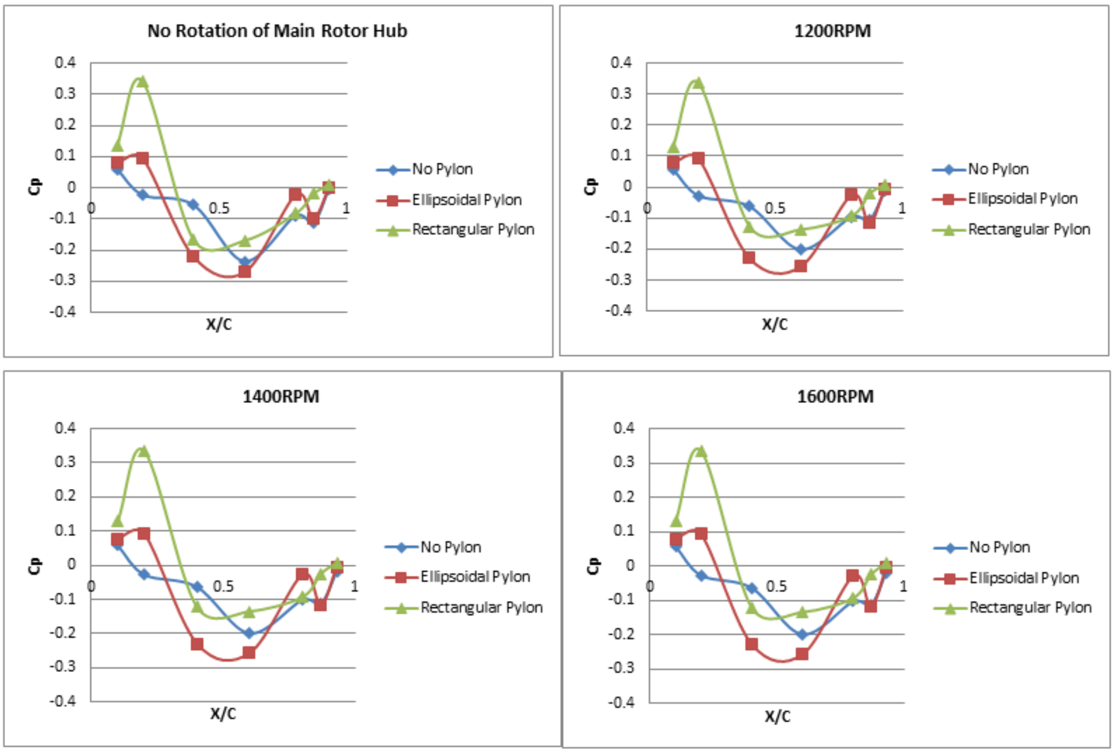


Figure 11: Graph of *Cp* against x/c for left fuselage with different configuration of pylon at different rotation of main rotor hub at 30 m/s speed

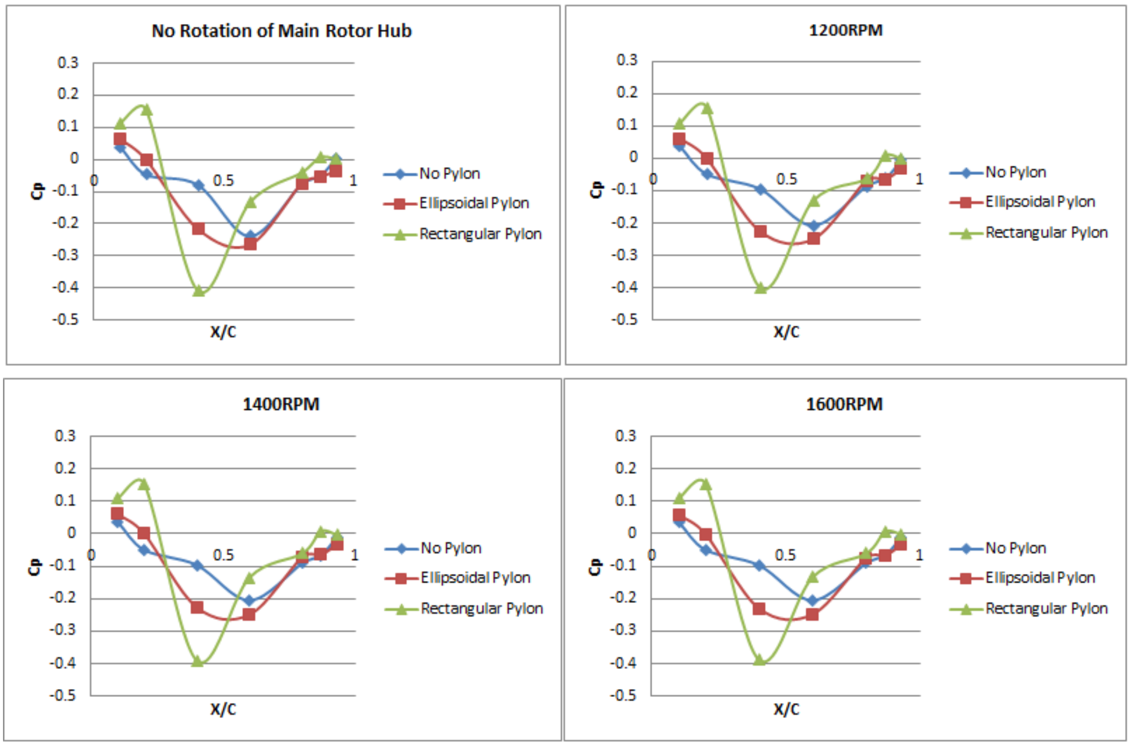


Figure 22: Graph of *Cp* against x/c for right fuselage with different configuration of pylon at different rotation of main rotor hub at 30 m/s speed

Figure 9 to 12 depict for the front area, rectangular pylon contributes the highest Cp that may testify highly turbulence wake occurred in this region. Meanwhile at the side of pylon which is at 0.4 x/c and 0.6 x/c, the Cp distributions are unsymmetrical due to extreme complex flow phenomena. At zero

RPM for both wind speeds when comparing to the No Pylon Configuration, the pressure for fuselage with ellipsoidal pylon configuration decreases but the trend is inversely for the fuselage with rectangular pylon configuration. Remarkably it can be seen that the trend of Cp along x/c is same for the all configurations.

CONCLUSION

T Results tell main-rotor-hub assembly's rpm and wind speed (or forward flight speed) do influencing the pressure distribution on the fuselage. Noticeable the change of pressure coefficient, Cp across the fuselage is quite drastic implying very high flow unsteadiness phenomenon due to rotation of main-rotor-hub. On top of that, it is found the pressure distributions are unsymmetrical for both sides of the fuselage, a testimony that the flow is complex which is agreeable with the findings made by Ishak et. al [11]. Results also conclude the presence of pylon does influencing the value of Cp, thus the flow unsteadiness. Hence, a pylon must be designed wisely in order to have the intended flow characteristics as it may significantly reduce the unsteady wake and consequently, the helicopter tail shake phenomena.

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