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REFERENCE DATA OF PRESSURE DISTRIBUTION ON THE SURFACES OF AIRFOILS HAVING THE NAMES BEGINNING WITH THE LETTER A (THE FIRST PART)

Abstract: *The results of the computer calculation of air flow around the airfoils having the names beginning with the letter A are presented in the article. The contours of pressure distribution on the surfaces of the airfoils at the angles of attack of 0, 15 and -15 degrees in conditions of the subsonic airplane flight speed were obtained.*

Key words: *the airfoil, the angle of attack, pressure, the surface.*
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Introduction

The creation of reference materials that determine the most accurate pressure distribution on the airfoils surfaces is an actual task of airplane aerodynamics.

Materials and methods

The study of air flow around the airfoils was carried out in a two-dimensional formulation by means of the computer calculation in the *Comsol Multiphysics* program. The airfoils in the cross section were taken as objects of research [1-10].

In this work, the airfoils having the names beginning with the letter *A* were adopted. Air flow around the airfoils was carried out at the angles of attack (α) of 0, 15 and -15 degrees. The flight speed of the airplane in each case was subsonic. The airplane flight in the atmosphere was carried out under normal weather conditions.

The following airfoils were used for the calculation:

12% JOUKOWSKI is the 12% Joukowski airfoil, max. thickness of 11.8% at 25% of the chord, max. camber of 0% at 9.5% of the chord;

12A 9,00% is the Rolf Girsberger RG 12A airfoil, max. thickness of 9% at 34.4% of the chord, max. camber of 1.8% at 34.4% of the chord;

20-32C is the Dillner 20-32-C low Reynolds number airfoil, max. thickness of 8% at 20% of the chord, max. camber of 6.9% at 40% of the chord;

A18 (original) is the Archer A18 F1C free flight airfoil (original), max. thickness of 7.3% at 30% of the chord, max. camber of 3.9% at 45% of the chord;

A18 (smoothed) is the Archer A18 F1C free flight airfoil (smoothed), max. thickness of 7.3% at 27.1% of the chord, max. camber of 3.8% at 49.3% of the chord;

A-93B17 is the airfoil, max. thickness of 9.2% at 30% of the chord, max. camber of 5.85% at 40% of the chord;

Abrial 17 is the airfoil, max. thickness of 9.2% at 30% of the chord, max. camber of 5.85% at 40% of the chord;

AH 79-100 A is the Althaus AH 79-100A airfoil, max. thickness of 10% at 27.9% of the chord, max. camber of 3.6% at 56.5% of the chord;

AH 79-100 B is the Althaus AH 79-100B airfoil, max. thickness of 10% at 30.9% of the chord, max. camber of 6.4% at 50% of the chord;

AH 79-100 C is the Althaus AH 79-100C airfoil, max. thickness of 9.9% at 30.9% of the chord, max. camber of 6.7% at 50% of the chord;

AH21 is the Andrew Hollom AH 21 airfoil (original 9% version), max. thickness of 7% at 34.9% of the chord, max. camber of 1.8% at 54.8% of the chord;

AH21-7 is the Andrew Hollom AH 21 airfoil (7% version), max. thickness of 9% at 34.9% of the chord, max. camber of 2.3% at 54.8% of the chord;

AH-6-40-7 is the Althaus AH 6-407 airfoil, max. thickness of 6.9% at 20% of the chord, max. camber of 5.5% at 40% of the chord;

AH-7-47-6 is the Althaus AH 7-476 airfoil, max. thickness of 5.9% at 20% of the chord, max. camber of 6.2% at 50% of the chord;

ANDRUKOV is the airfoil, max. thickness of 6.62% at 20% of the chord, max. camber of 6.39% at 40% of the chord;

Antares is the airfoil, max. thickness of 10.7% at 30% of the chord, max. camber of 3.21% at 40% of the chord;

AQUILA is the AQUILA R/C sailplane airfoil, max. thickness of 9.38% at 31.33% of the chord, max. camber of 4.05% at 34.67% of the chord;

AQUILA 9,3% smoothed is the AQUILA R/C sailplane airfoil, max. thickness of 9.4% at 31.3% of the chord, max. camber of 4% at 34.7% of the chord;

ARA-D 10% is the Aeronautical Research Association/Bocci-Dowty Rotol ARA-D 10% thick propeller airfoil, max. thickness of 10% at 25% of the chord, max. camber of 4% at 35% of the chord;

ARA-D 13% is the Aeronautical Research Association/Bocci-Dowty Rotol ARA-D 13% thick propeller airfoil, max. thickness of 13% at 25% of the chord, max. camber of 3.6% at 30% of the chord;

ARA-D 20% is the Aeronautical Research Association/Bocci-Dowty Rotol ARA-D 20% thick propeller airfoil, max. thickness of 20% at 25% of the chord, max. camber of 3.8% at 25% of the chord;

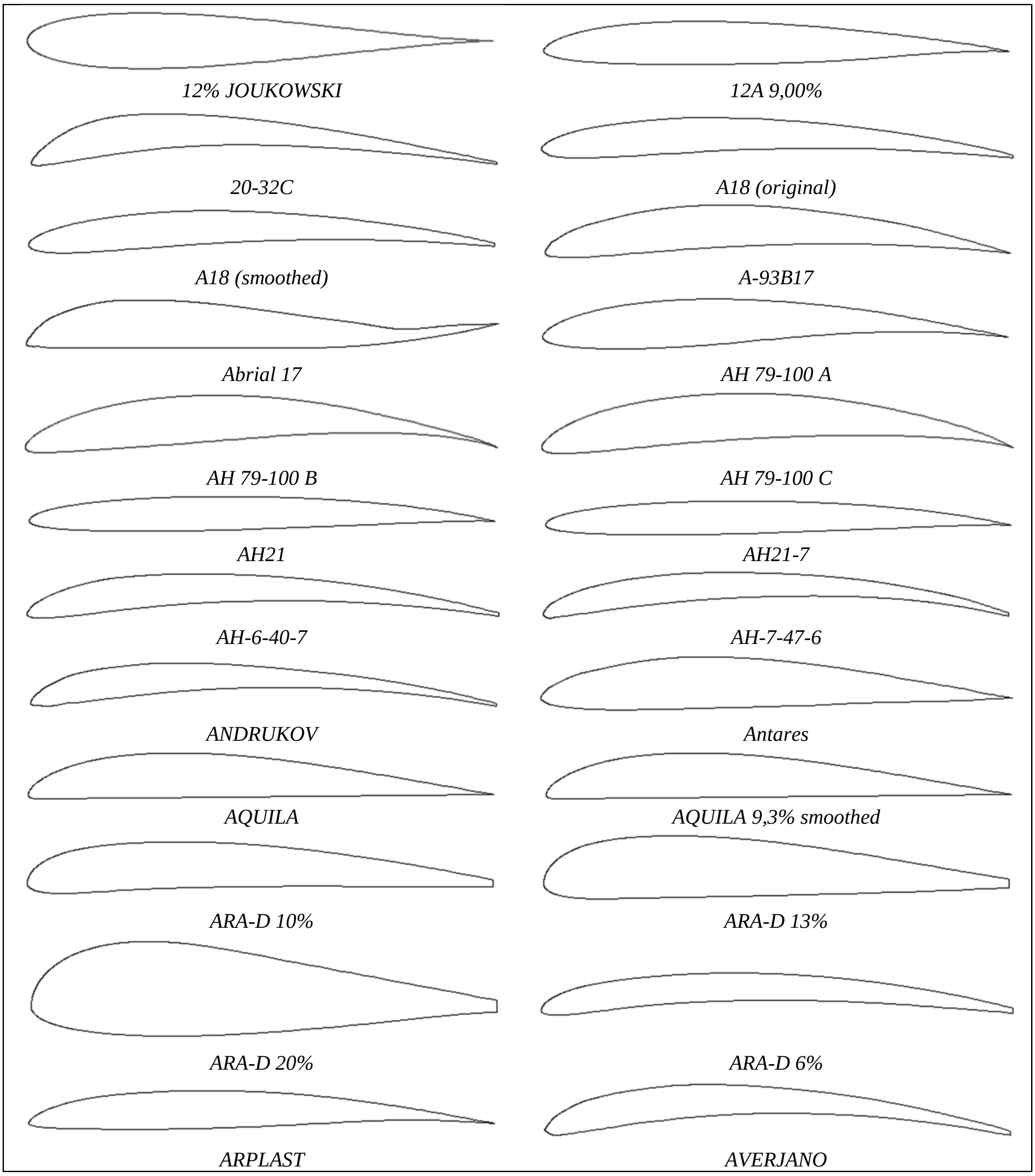
ARA-D 6% is the Aeronautical Research Association/Bocci-Dowty Rotol ARA-D 6% thick propeller airfoil, max. thickness of 6% at 20% of the chord, max. camber of 5% at 45% of the chord;

ARPLAST is the airfoil, max. thickness of 7.97% at 35% of the chord, max. camber of 3% at 50% of the chord;

AVERJANO is the airfoil, max. thickness of 7.2% at 25% of the chord, max. camber of 7.55% at 40% of the chord.

The studied geometric shapes of the airfoils in the cross section are presented in the Table 1.

Table 1. The geometric shapes of the airfoils in the cross section.



Results and discussion

The calculated pressure contours on the surfaces of the airfoils at the different angles of attack are presented in the Tables 2-25. The calculated magnitudes on the scale can be represented as the basic magnitudes when comparing the pressure drop under conditions of changing the angle of attack of the airfoils.

Negative pressure is observed in the zone of maximum thickness at the zero angle of attack on the upper and lower surfaces of the symmetrical airfoil (12% JOUKOWSKI). For the non-symmetrical airfoils (including those with curvature), the negative pressure gradient is formed on the upper surface, and the positive pressure gradient is formed on the lower surface. The smoothed airfoil (for example, the A18 (smoothed) airfoil) is characterized by a six-fold increase in the drag at the leading edge, compared to the original airfoil. Maximum positive pressure occurs at the leading edge of the A18 (smoothed) airfoil.

The drag (negative pressure on the leading edge) increases at the angles of attack of 15 and -15 degrees. For the some airfoils, maximum increase in negative pressure on the leading edge occurs at the angle of attack of 15 degrees (12A 9,00%, A18 (original), A18 (smoothed), A-93B17, Abrial 17, AH 79-100 B, AH 79-100 C, AH21, AH21-7, AH-6-40-7, AH-7-47-6, ANDRUKOV, Antares, AQUILA, AQUILA 9,3% smoothed, ARA-D 6%, ARPLAST, AVERJANO), and for the some airfoils occurs at the angle of attack of -15 degrees (12% JOUKOWSKI, 20-32C, AH 79-100 A, ARA-D 10%, ARA-D 13%, ARA-D 20%).

Table 2. The pressure contours on the surfaces of the 12% JOUKOWSKI airfoil.

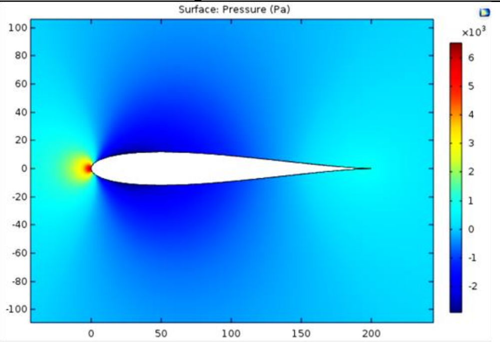
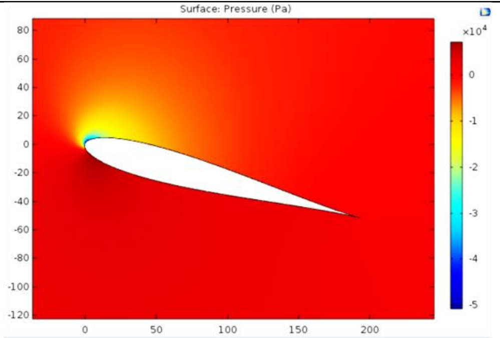
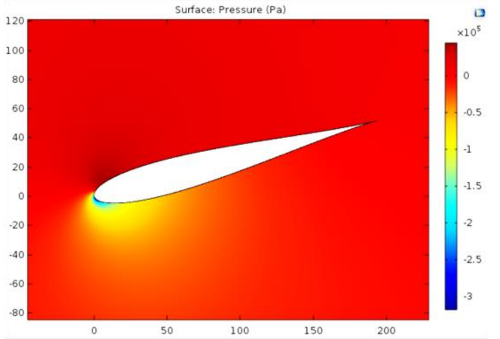
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 3. The pressure contours on the surfaces of the 12A 9,00% airfoil.

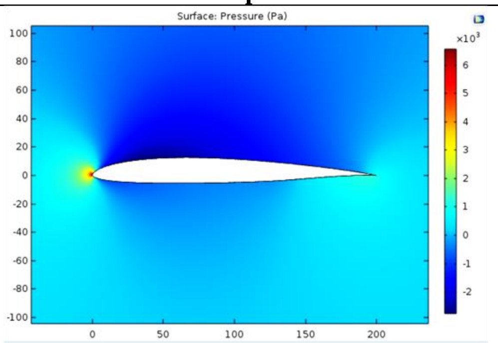
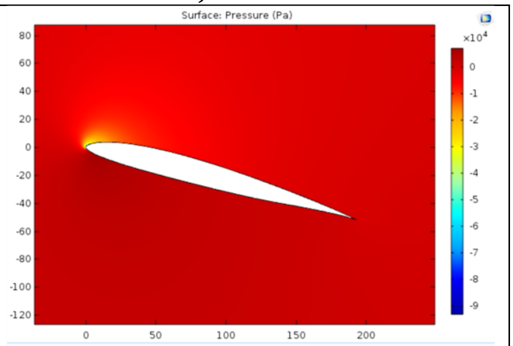
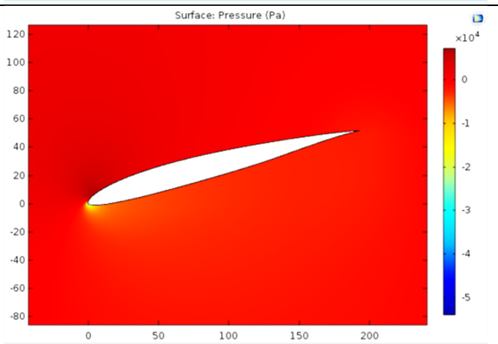
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 4. The pressure contours on the surfaces of the 20-32C airfoil.

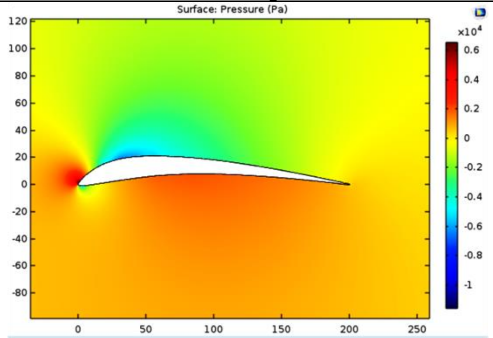
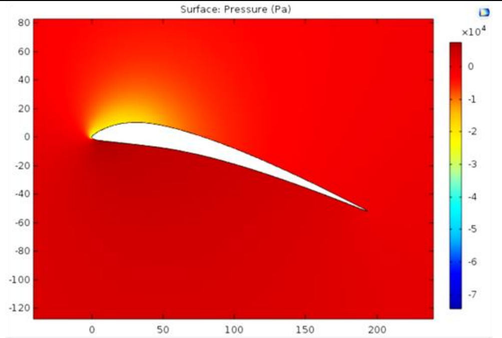
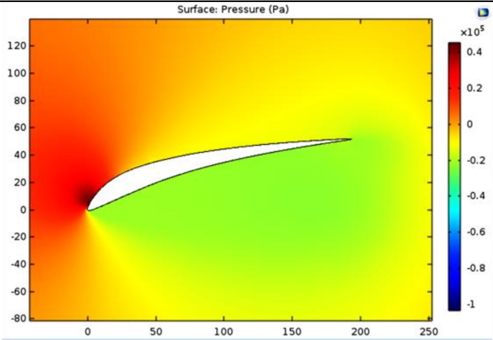
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 5. The pressure contours on the surfaces of the A18 (original) airfoil.

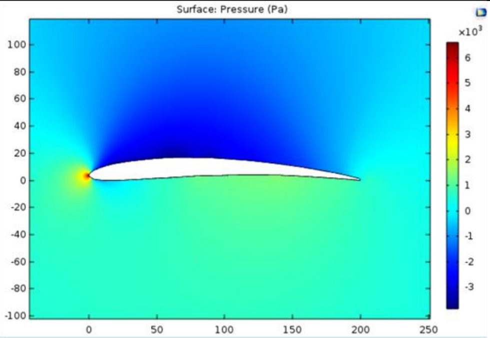
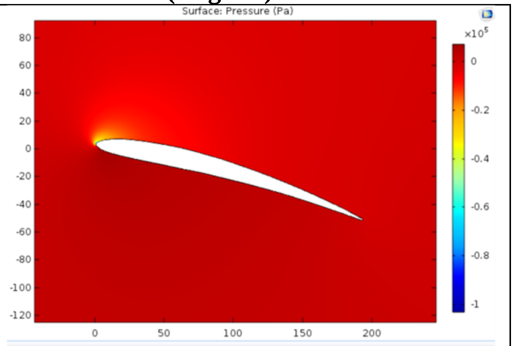
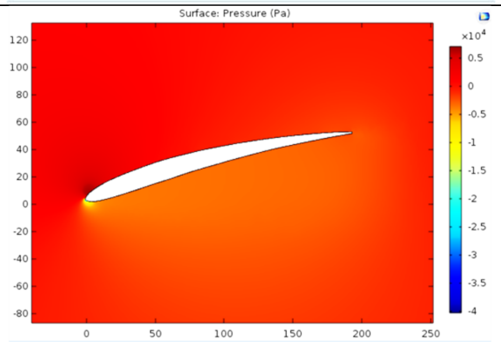
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 6. The pressure contours on the surfaces of the A18 (smoothed) airfoil.

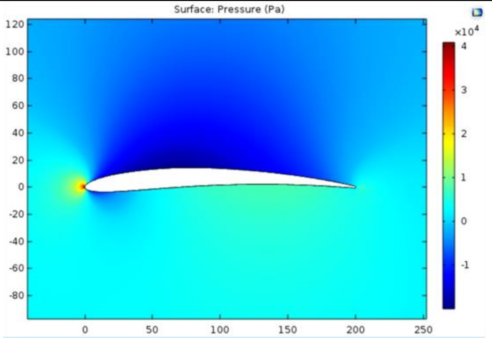
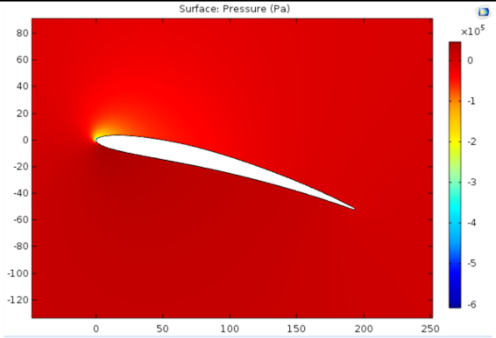
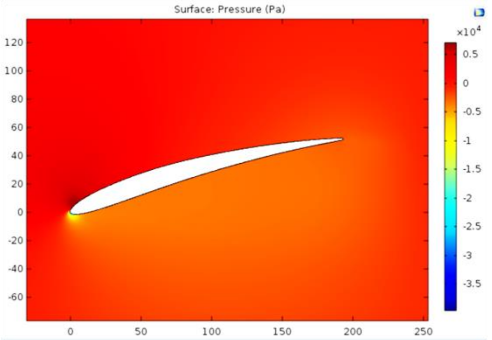
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 7. The pressure contours on the surfaces of the A-93B17 airfoil.

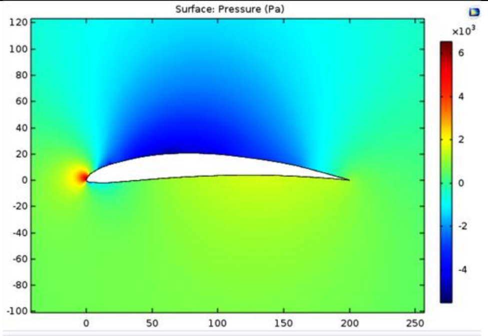
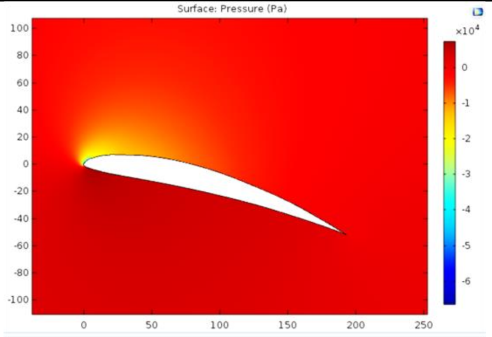
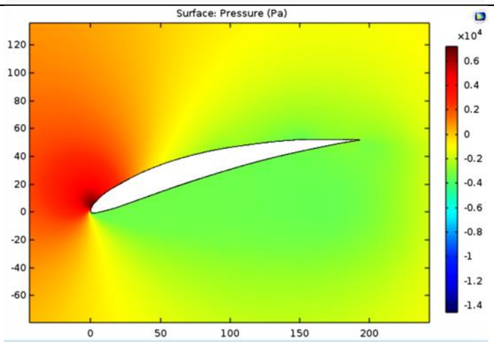
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 8. The pressure contours on the surfaces of the Abrial 17 airfoil.

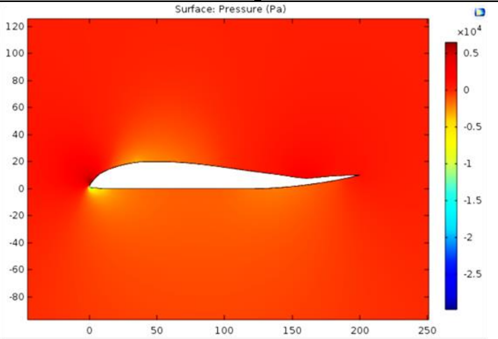
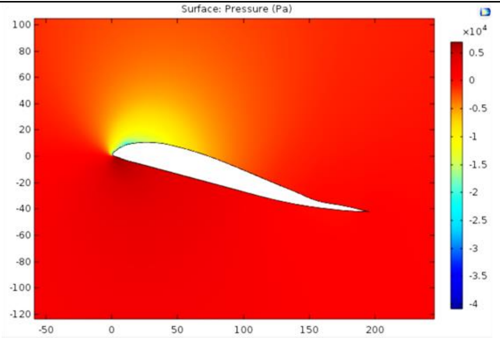
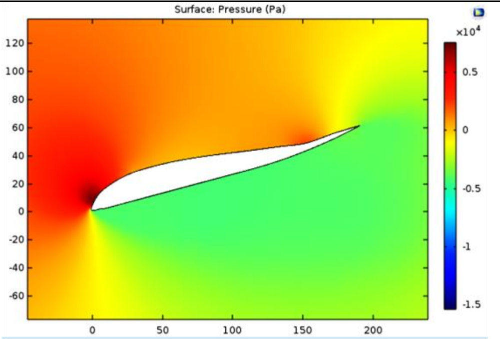
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 9. The pressure contours on the surfaces of the AH 79-100 A airfoil.

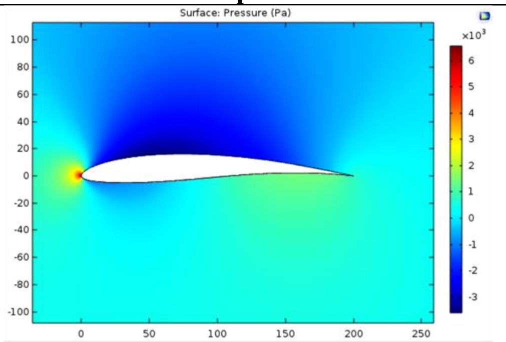
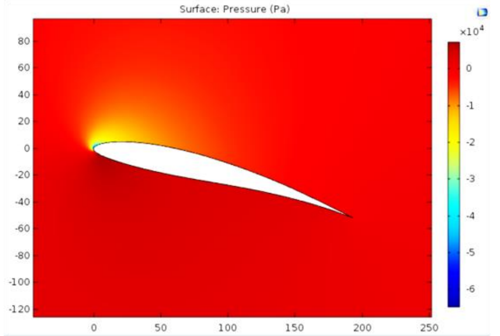
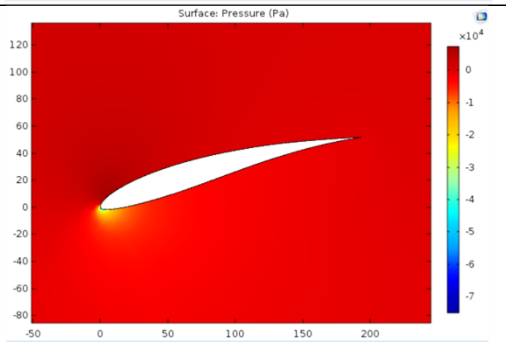
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 10. The pressure contours on the surfaces of the AH 79-100 B airfoil.

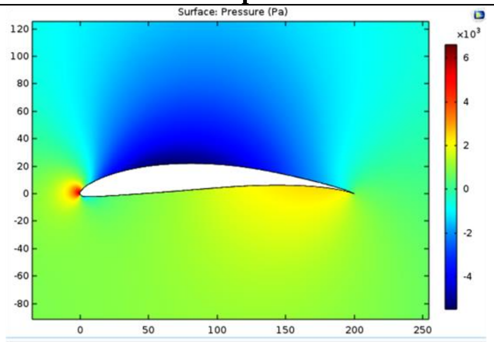
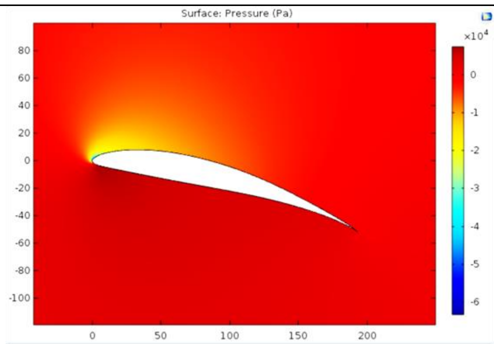
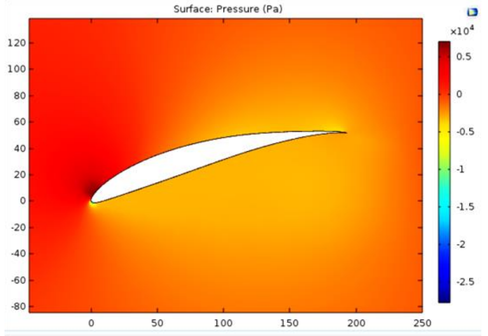
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 11. The pressure contours on the surfaces of the AH 79-100 C airfoil.

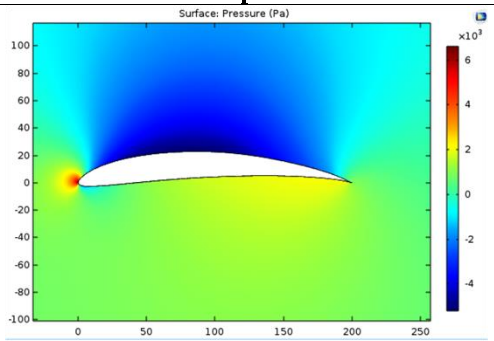
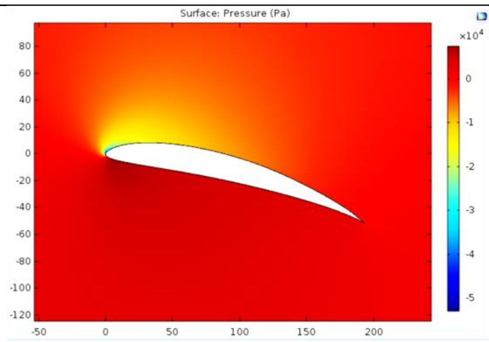
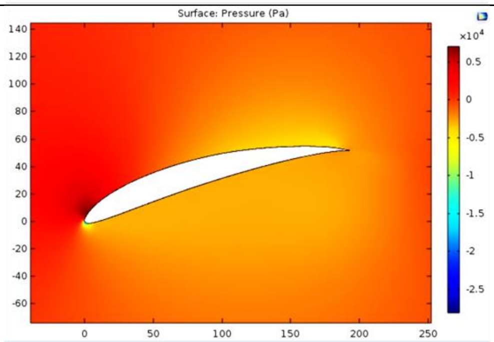
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 12. The pressure contours on the surfaces of the AH21 airfoil.

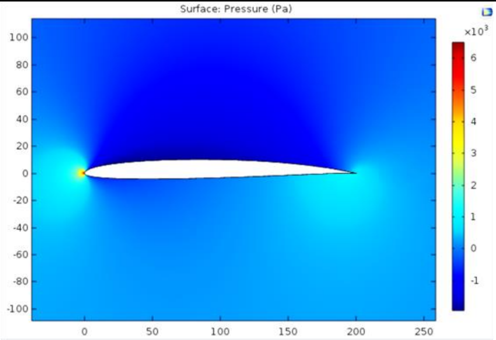
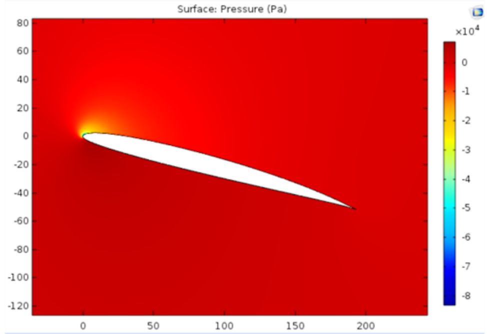
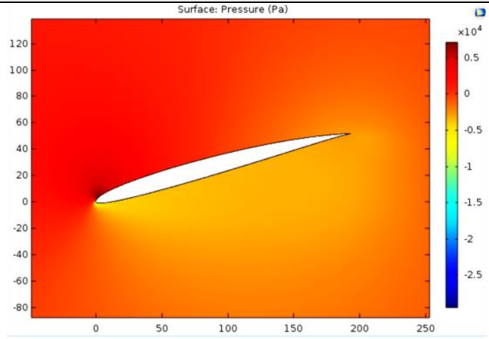
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 13. The pressure contours on the surfaces of the AH21-7 airfoil.

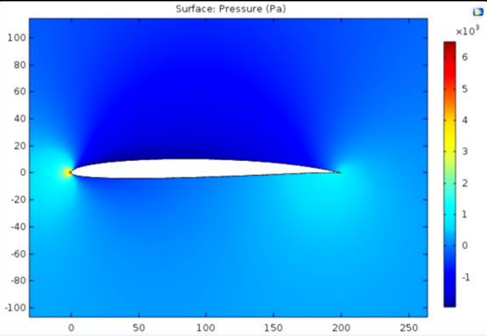
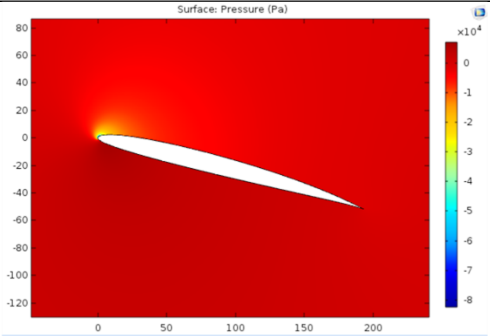
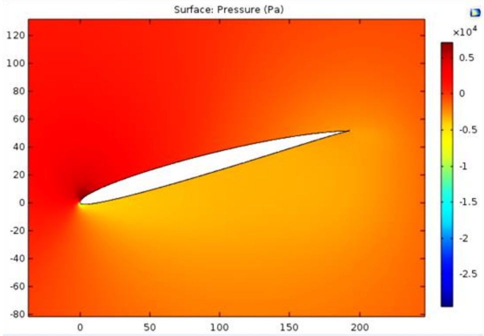
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 14. The pressure contours on the surfaces of the AH-6-40-7 airfoil.

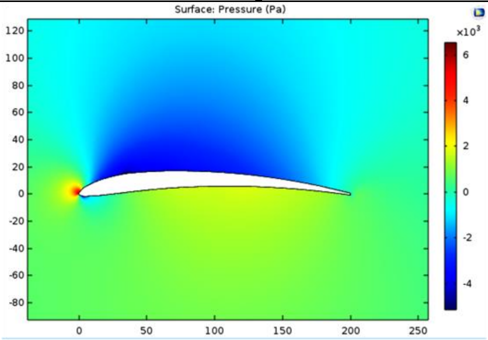
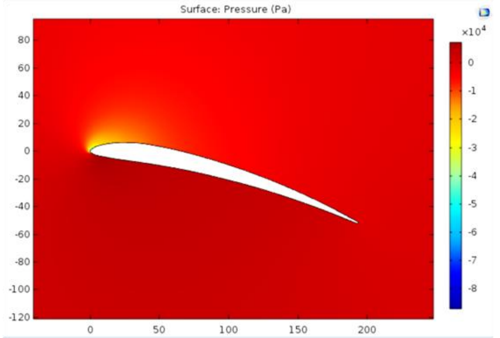
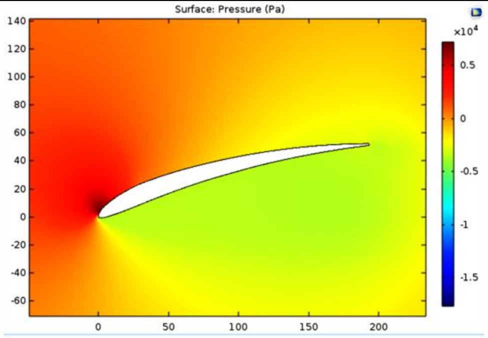
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 15. The pressure contours on the surfaces of the AH-7-47-6 airfoil.

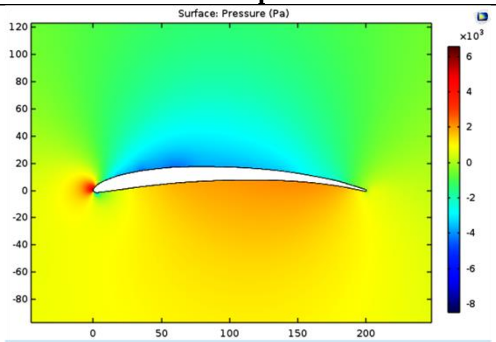
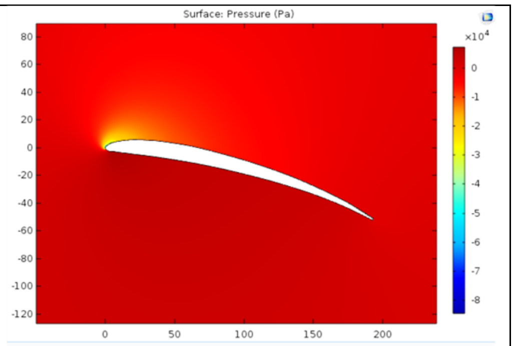
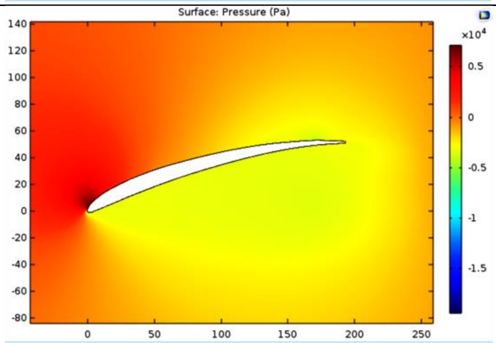
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 16. The pressure contours on the surfaces of the ANDRUKOV airfoil.

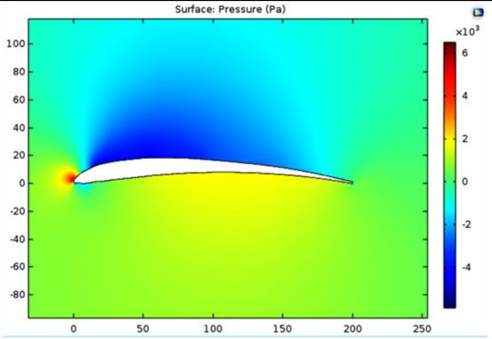
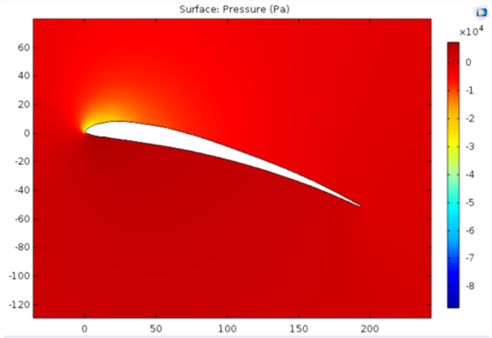
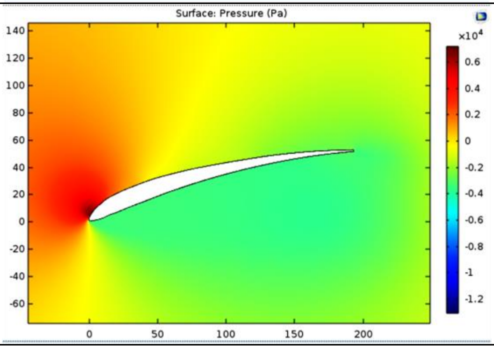
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 17. The pressure contours on the surfaces of the Antares airfoil.

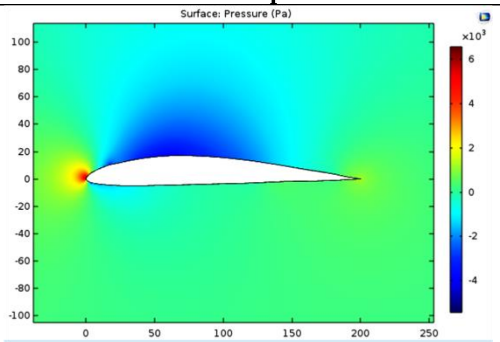
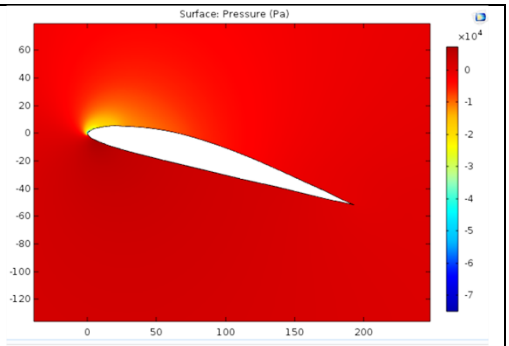
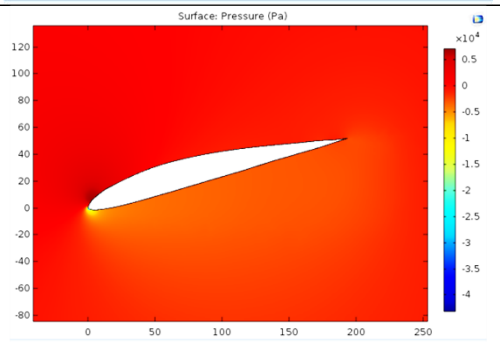
$\alpha = 0$ degrees		$\alpha = 15$ degrees	
$\alpha = -15$ degrees			

Table 18. The pressure contours on the surfaces of the AQUILA airfoil.

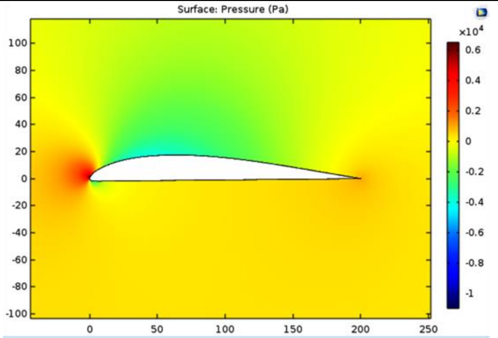
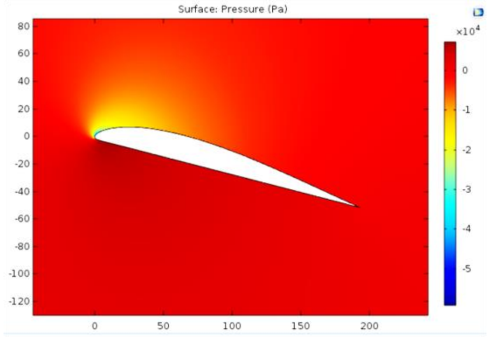
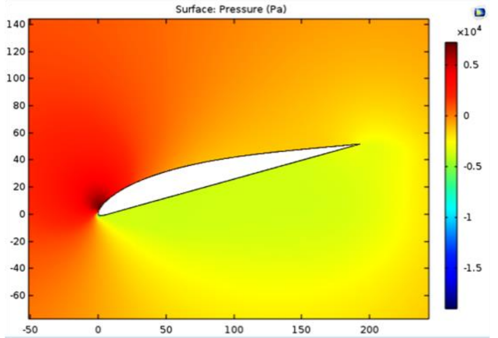
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 19. The pressure contours on the surfaces of the AQUILA 9,3% smoothed airfoil.

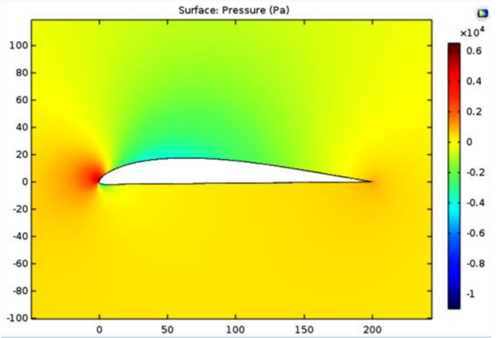
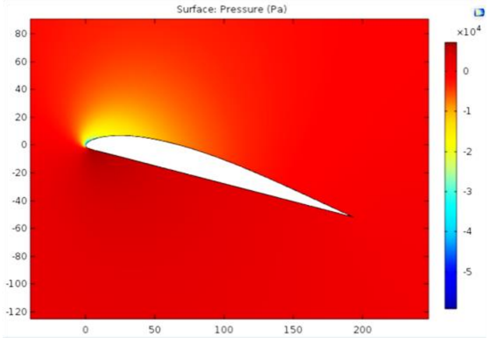
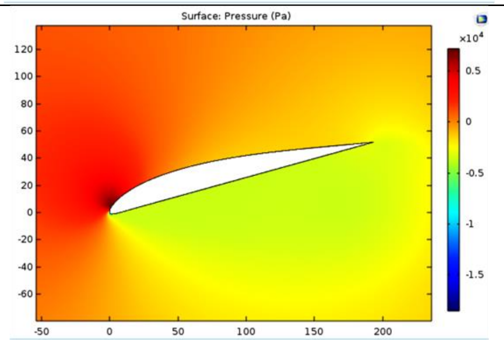
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 20. The pressure contours on the surfaces of the ARA-D 10% airfoil.

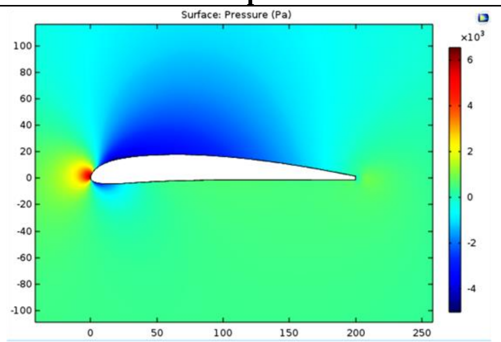
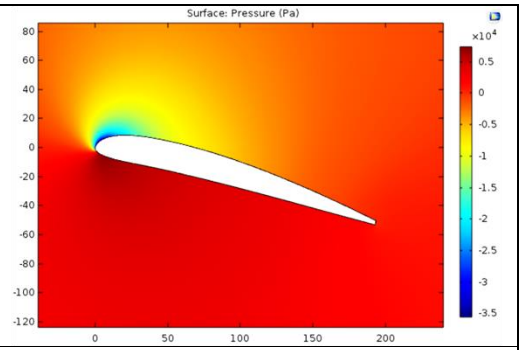
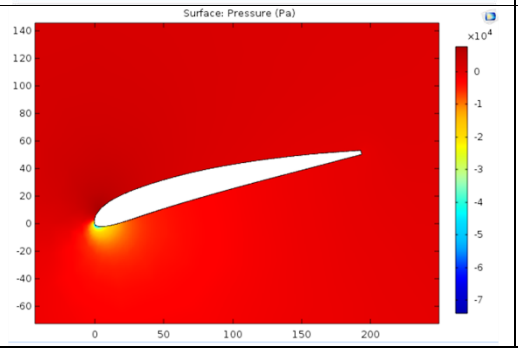
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 21. The pressure contours on the surfaces of the ARA-D 13% airfoil.

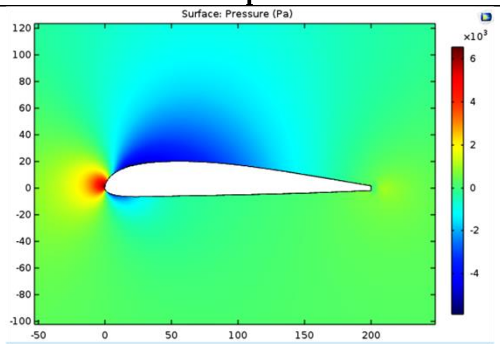
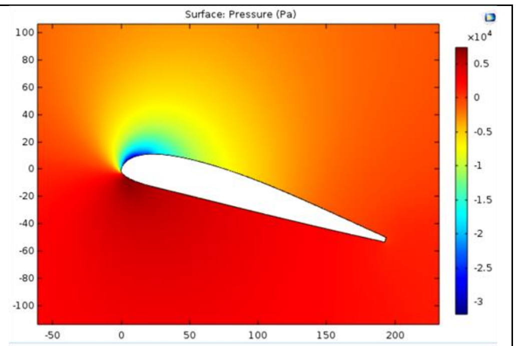
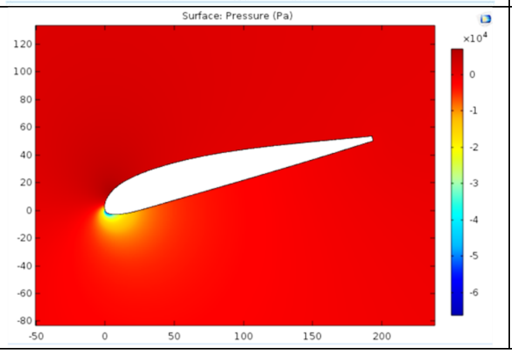
α = 0 degrees		α = 15 degrees	
α = -15 degrees			

Table 22. The pressure contours on the surfaces of the ARA-D 20% airfoil.

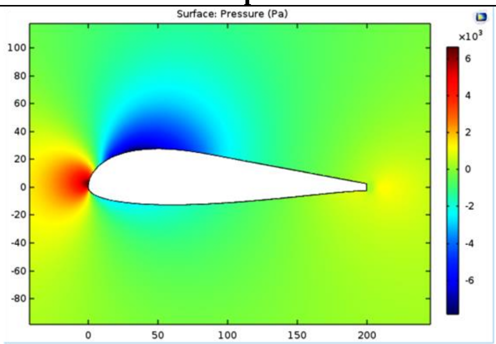
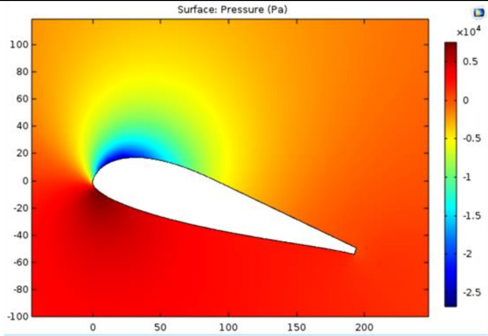
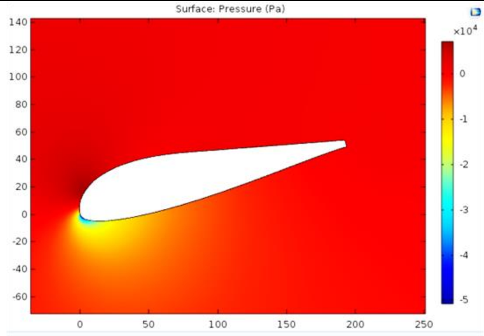
$\alpha = 0$ degrees 	$\alpha = 15$ degrees 
$\alpha = -15$ degrees 	

Table 23. The pressure contours on the surfaces of the ARA-D 6% airfoil.

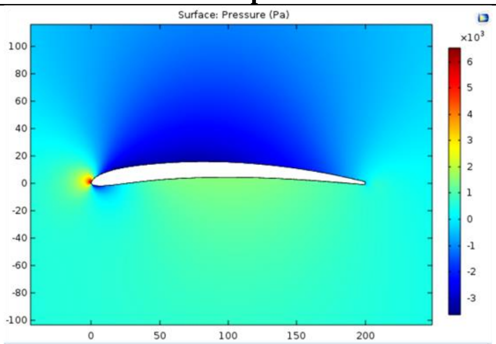
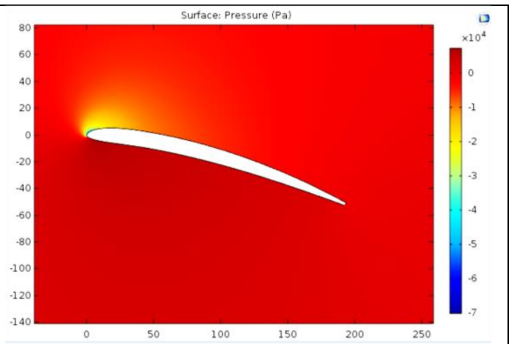
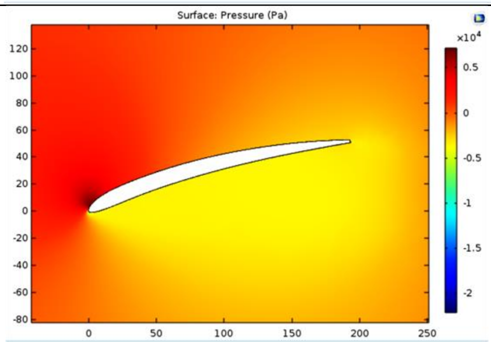
$\alpha = 0$ degrees 	$\alpha = 15$ degrees 
$\alpha = -15$ degrees 	

Table 24. The pressure contours on the surfaces of the ARPLAST airfoil.

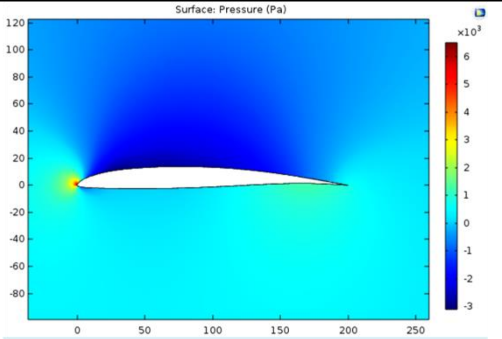
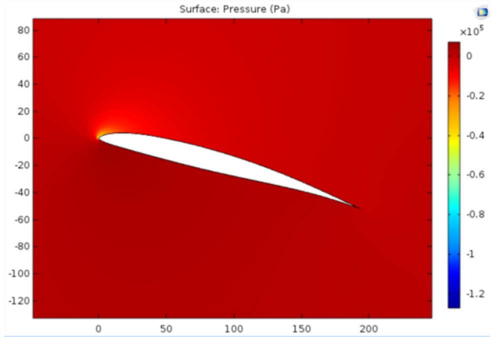
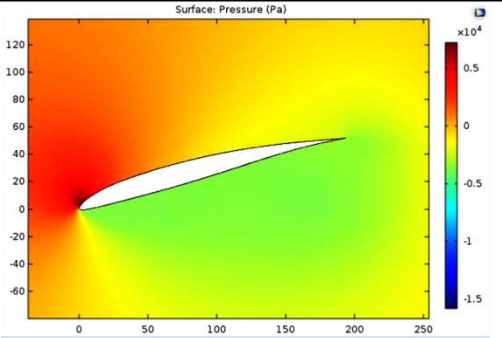
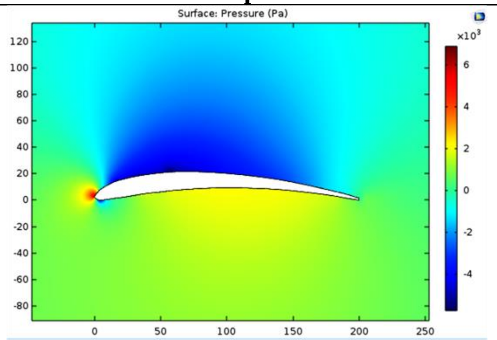
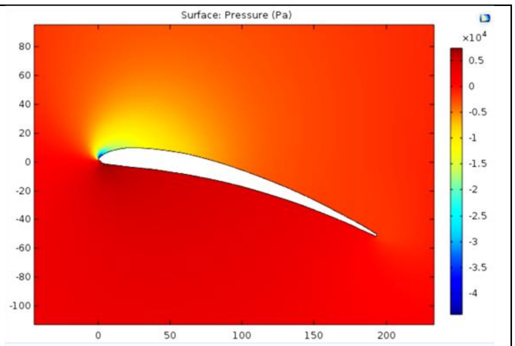
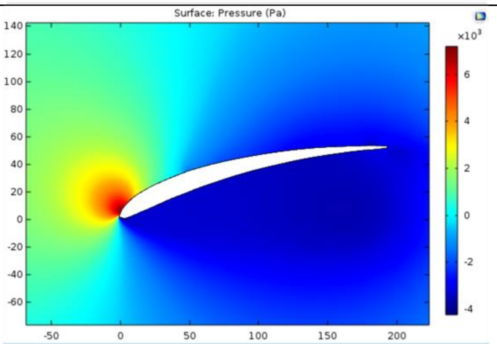
α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Table 25. The pressure contours on the surfaces of the AVERJANO airfoil.

α = 0 degrees 	α = 15 degrees 
α = -15 degrees 	

Conclusion

The smoothed airfoil increases the drag than the original airfoil. The action area of negative pressure increases with increasing thickness of the airfoil. The A18 (smoothed) airfoil at the angle of attack of 15 degrees is subjected to maximum pressure. The AVERJANO airfoil is subjected to almost identical pressures in the magnitude at the angles of attack of 0 and 15 degrees.

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