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Improvement of Aerodynamic Characteristics of an Airfoil by Surface Modification

Rubiat Mustak[1], Md. Harun-Or-Rashid Molla[2]
[1,2]Department of Mechanical Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

ABSTRACT: *The current work describes exchange in aerodynamic characteristics of an airfoil by way of applying certain surface modifications in the shape of dimples. At first surface change that is taken into consideration right here is hexagonal dimples at the wing model. A comparative take a look at displaying variance in lift and drag of modified airfoil model at different angle of attacks is performed. The surface amendment that is being taken into consideration inside the given observe are dimples of hexagonal shapes. Until now those were unnoticed due to the fact dimples help in reduction of pressure drag. In case of aerodynamic bodies pressure drag may be very little as compared to bluff bodies. An airfoil is an aerodynamic body so dimples do now not affect to its drag a good deal at zero angle of attack, however as soon as airfoil attains a few angle of attack, wake formation begins due to boundary layer separation. Utility of dimples on aircraft wing model works in same manner as vortex generators. They induce turbulence which delays the boundary layer separation and decreases the wake and thereby reducing the pressure drag. This also assists in elevation of the aircraft. The outcomes had been in agreement that dimples at the surface of aircraft wing model does not have an effect on the pressure drag because it is already aerodynamic in form however it may affect its aerodynamics whilst the airfoil is at different angle of attacks.. This project indicates if the dimples that reduce a golfing ball's drag, can also alter flow dynamics around airfoil for better aerodynamic performance. Dimples delay the boundary layer separation via growing greater turbulence over the surface for that reason reducing the wake formation. This in turn reduces drag drastically. The airfoil profile considered in the present study is NACA-4415 with uniform cross-section throughout the length of airfoil.Subsonic flows are considered for the observation .For design purpose solid works software is used. Two distinct models without dimples and with hexagonal dimples have been constructed. All the models are prepared through timber and the research is carried out with the use of a 100×100×100 cm subsonic wind tunnel. From the investigations it has been determined that the flow separation on the airfoil can be delayed by using hexagonal dimples on the upper surface. Flow separation occurs at 12° angle of attack in the regular surface. But for surface having hexagonal dimples it will occurs at 16° angle of attack. That indicates the surface having hexagonal dimples successfully controls the flow separation and increases the lift force of an airfoil.*

Keywords: *Airfoil, Boundary layer separation, Drag reduction, Lift, Vortex generator*

I. INTRODUCTION

From the start of human race, man has continually dreamt of flying and on December 17, 1903 Wright brothers gave human race new wings and was hoping for non-stop endeavours on this field. Now we've advanced to wonderful quantity in air but nonetheless after so much has been done there are certain constraints binding us. Freedom inside the air remains no longer entire. Non-stop attempts are being made to increase freedom in air, be it speed, size or manoeuvrability. From commercial jetliners to supersonic combatants, there was an exponential boom inside the aviation industry. Nonetheless there's giant scope for further upgrades. Here is an examine that makes one such try.

At present, exclusive styles of surface modifications are being studied to improve the manoeuvrability of the aircraft. Vortex generators are the most often used adjustments to an aircraft surface. Vortex generators create turbulence by way of growing vortices which delays the boundary layer separation ensuing in lower of pressure drag and also increase in the angle of stall. It helps to reduce the pressure drag at excessive attitude of assault and additionally increases the overall lift of the aircraft.

The surface modification which is being considered within the given take a look at are dimples of hexagonal shapes. Application dimples on aircraft wing model works in same manner as vortex generators.

They induce turbulence which delays the boundary layer separation and reduces the wake and thereby lowering the pressure drag. Flow separation begins to occur at small angles of attack while attached flow over the wing is still dominant. As perspective of attack will increase, the separated areas on the top of the wing boom in length and hinder the wing's capacity to create lift. At the critical angle of attack, separated flow is so dominant that similarly increases in angle of attack produce less lift and massively extra drag. With the intention to confirm the impact of dimples, the following experimental study has been made from hexagonal dimpled airfoil. Via this observe we purpose at making aircrafts greater manoeuvrable by dimpled airfoils. Also we are seeking to enhancing overall performance by greater L/D ratio i.e. growing aerodynamic performance. Aerodynamic performance is one of the key parameters that determine the burden and price of an plane. Roughly speaking, an aircraft's range is directly proportional to its aerodynamic efficiency without any increase in fuel usage. Improved aerodynamics is essential to both business and military plane. For commercial aircraft, improved aerodynamics reduces operating expenses. It additionally drastically contributes to the country wide protection by enhancing performance and overall performance of military aircraft. The results justify the increase within the normal lift and reduction in drag of the airfoil.

II. EXPERIMENTAL SETUP AND PROCEDURE

Studies were conducted in the Aerodynamics Laboratory of Department of Mechanical Engineering (Khulna University of Engineering & Technology) with subsonic wind tunnel of 1 m× 1 m square test segment. The wind tunnel can be operated at a most air speed of forty three m/s and the turn table had a capability for setting an angle of attack of 45 degree. Figure -1 indicates a schematic of the experimental set up. A small sized version is suitable to take a look at the aerodynamic traits for the experiments. If we choice to study the aerodynamic traits of a huge model, a huge scale wind tunnel facility is essential for trying out or the inflatable wing must be appreciably scaled down to suit the same old wind tunnel size violating the Reynolds number analogy requirements. Furthermore, it would be hard to aid the inflatable wing a ideal mind-set in those wind tunnel experiments. For the reason that vertical a part of the aerodynamic force produces the lifting force essential to suspend the weight. We're specifically inquisitive about the aerodynamic characteristics of hexagonal model. The model changed into positioned in the center of the take a look at section supported by means of flat iron bar. For the purpose of measuring the surface pressure a box consists of the sensors turned into positioned outdoor of the wind tunnel test section. The surface of the model is drilled via 1.5 mm diameter holes and small sizes tubes are placed in the drilled holes. Tubes having small diameter have been used to attach among the tubes within the model and the sensors of the aero lab measurement system. Surface pressure of the model at different points was measured. There is an angle measuring instrument to measure the angle of attack. For a consistent motor speed of the wind tunnel, Difference of the interior surface pressure of wind tunnel and the surface pressure of the model has been measured. For this experiment NACA 4415 airfoil profile has been decided on for wing model creation. Two forms of model have been prepared shown in Figure-2. One is (a) regular surface model and another one is (b) Dimpled (Hexagonal) surface model. All the models are organized via timber. The chord of ordinary surface airfoils is 210 mm and the chord of dimpled surface airfoil is also 210mm.

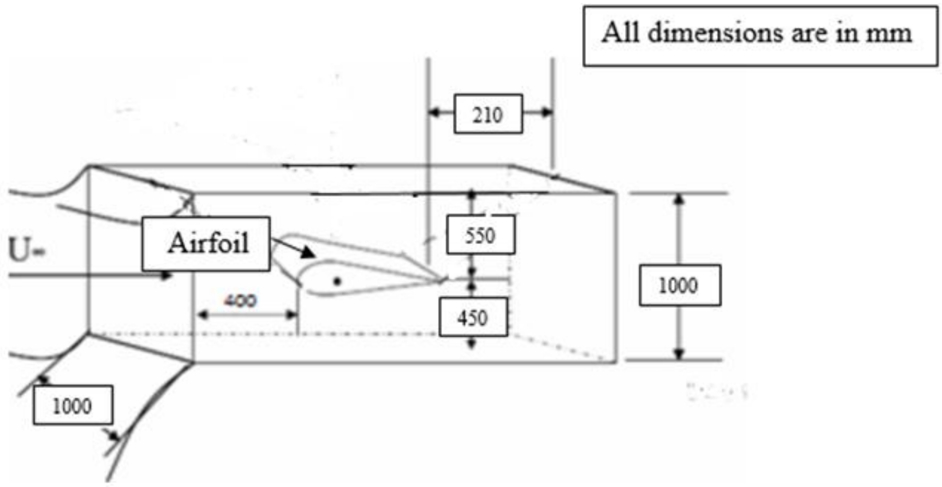

Fig. 1(a): Schematic diagram of wind tunnel test section

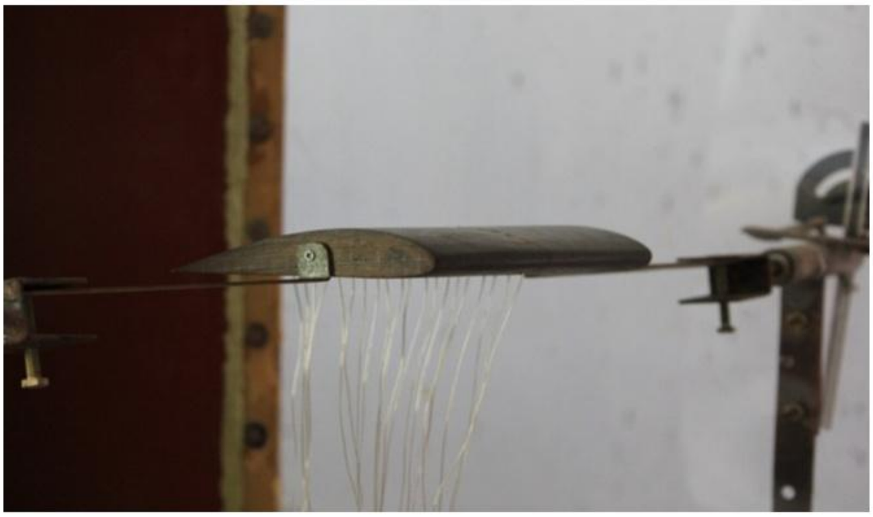

Fig.1(b). Experimental Setup for the experiment

Fig. 2(a). Constructed model with regular surface.

Fig. 2(b). Constructed model with hexagonal dimples

III. RESULTS AND DISCUSSION

The effects of surface pressure distributions are shown in Figures 3 to 10 for normal and hexagonal dimpled surface model. As shown in graph there may be no flow separation happens for each version (regular and dimpled) at zero angle of attack. As the attack attitude improved from 0° to 12°, go with the flow separation arise at regular surface version. As the attack perspective extended from 12° to 14° clear go with the flow separation regarded at the top surface. At angle of attack 12° go with the flow stays attached with the upper surface in case of dimpled airfoil. At 16° angle of attack the flow is separated from the upper surface in case of hexagonal dimpled surface. From the investigations it has been located that the flow separation at the airfoil may be delayed via the usage of the hexagonal dimples on the higher surface. Flow separation occurs at 12° angle of attack in the regular surface. However for surface having hexagonal dimples it takes place at 16° perspective of attack. That shows the surface having dimples effectively controls the flow separation and will increase the lift force of an airfoil. Dimples put off the boundary layer separation via developing more turbulence over the surface accordingly lowering the wake formation. Most significantly this may be quite effective at different the angle of attacks and also can change angle of stall to a great extent. A stall is a situation in aerodynamics and aviation wherein the perspective of assault increases past a positive point such that the elevation starts off evolved to decrease. It is seen from figure-11 hexagonal dimples change the angle of stall. This in turn reduces drag drastically. The probable surface pressure distribution for both regular and dimpled (hexagonal) is shown below at various angle of attack.

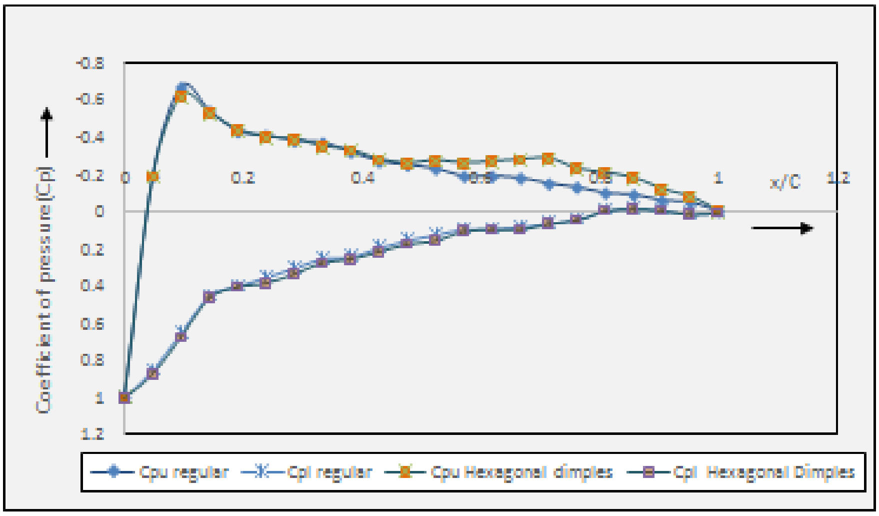

Fig. 3. Coefficient of pressure vs distance at 0° angle of attack.

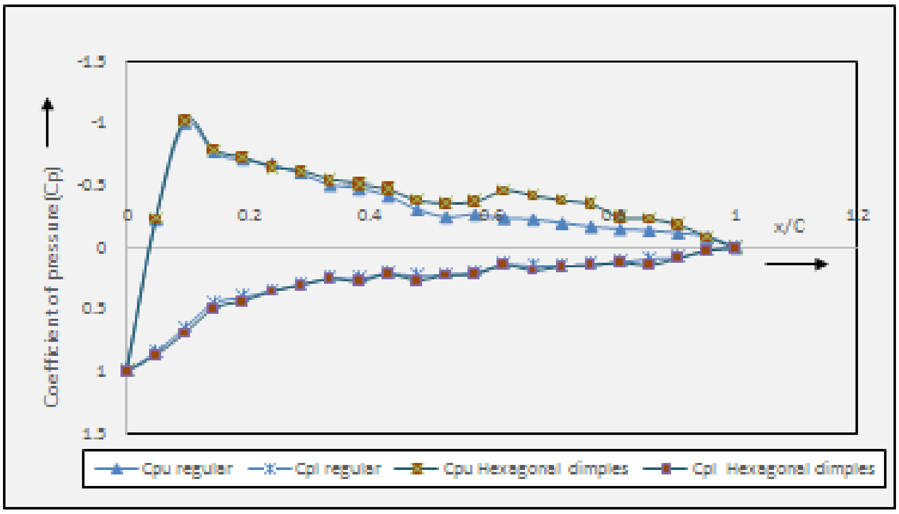

Fig. 4. Coefficient of pressure vs distance at 5° angle of attack.

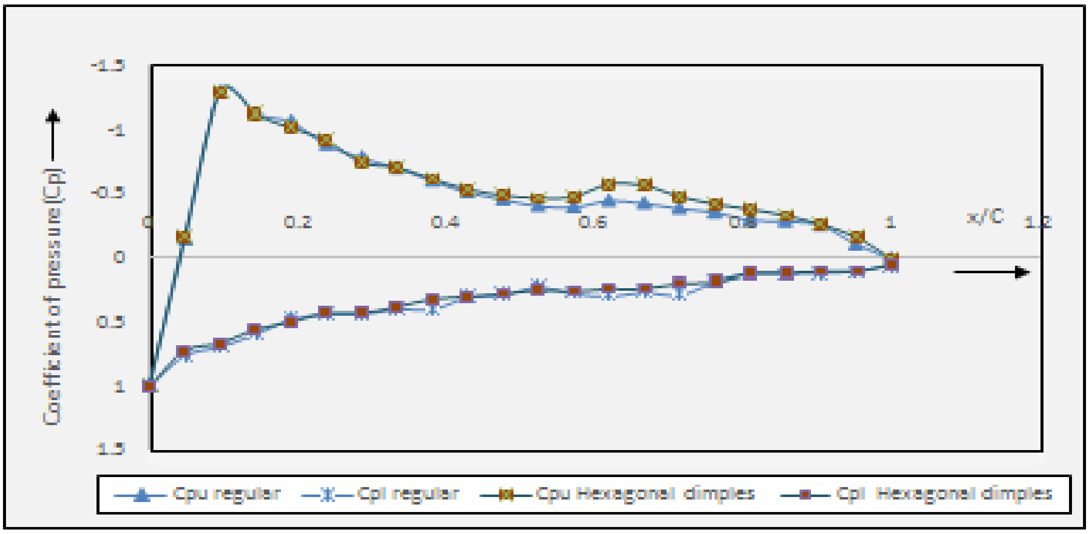

Fig. 5. Coefficient of pressure vs distance at 8° angle of attack.

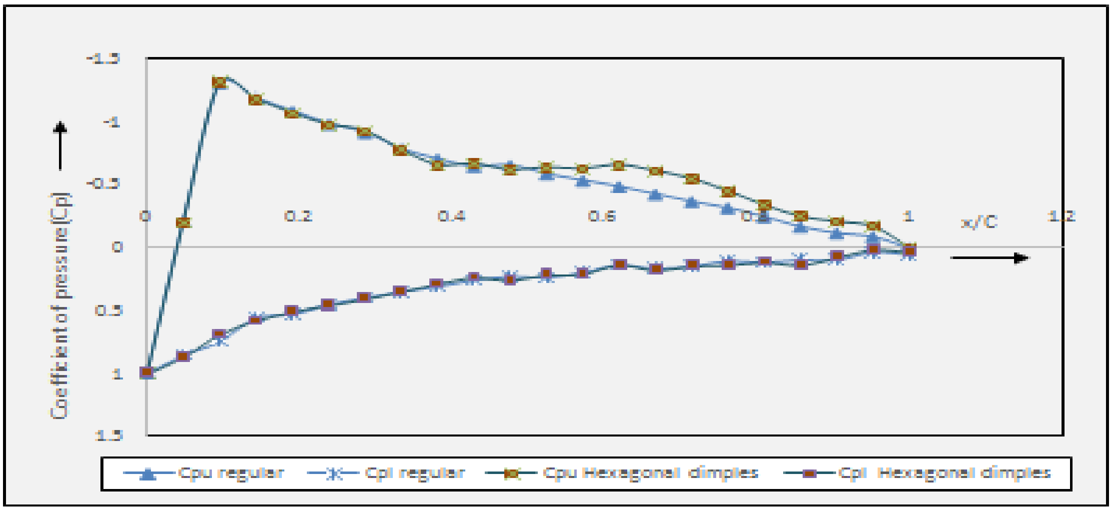

Fig. 6. Coefficient of pressure vs distance at 10° angle of attack.

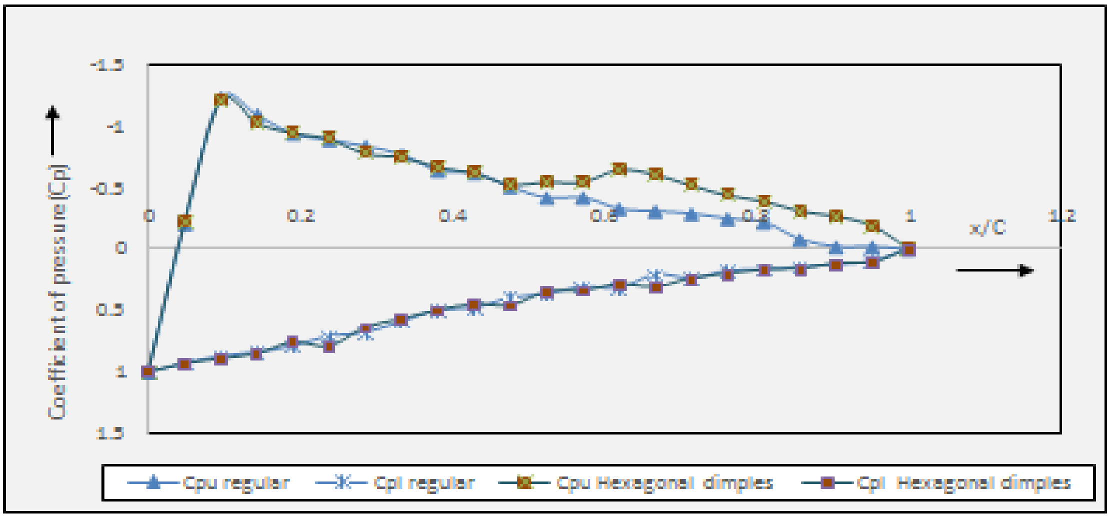

Fig. 7. Coefficient of pressure vs distance at 12° angle of attack.

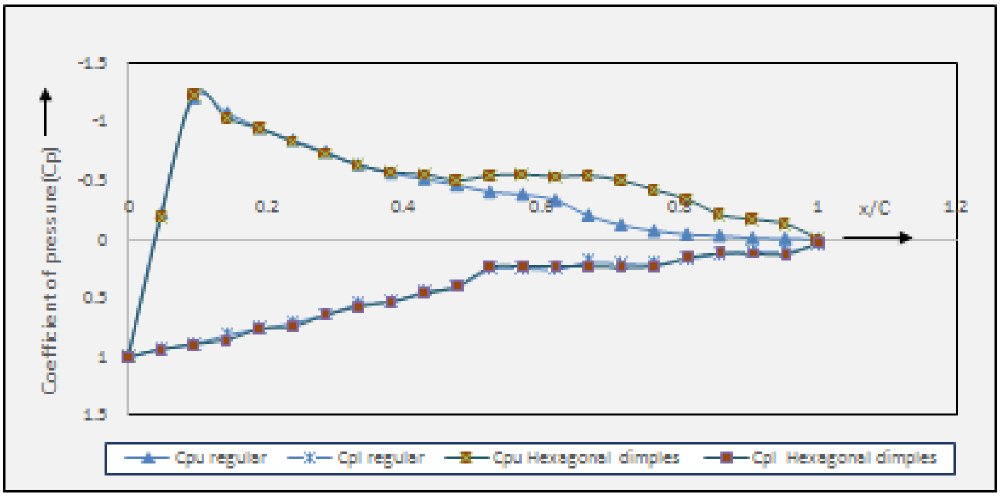

Fig. 8. Coefficient of pressure vs distance at 14° angle of attack.

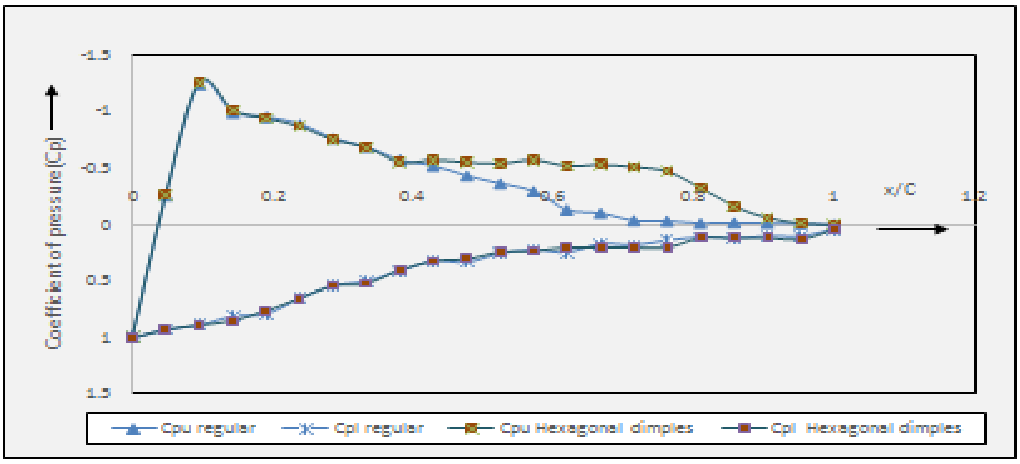

Fig. 9. Coefficient of pressure vs distance at 16° angle of attack.

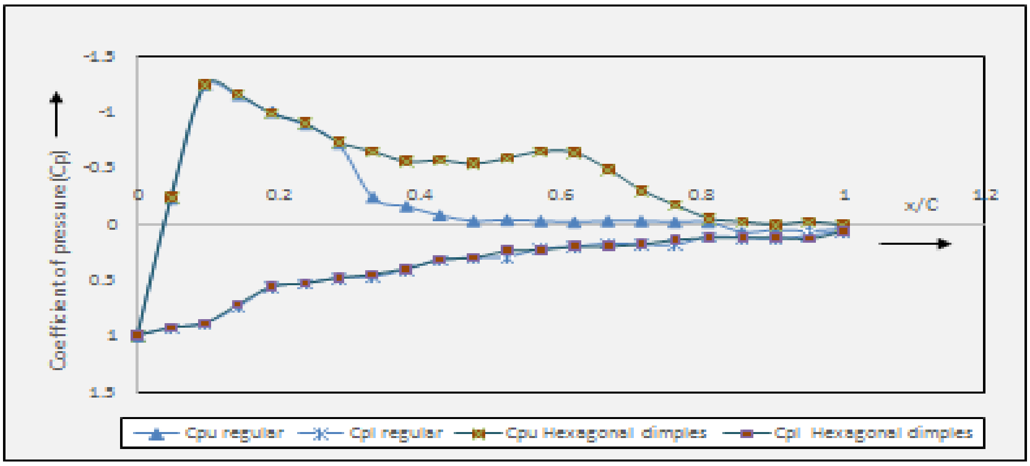

Fig. 10. Coefficient of pressure vs distance at 18° angle of attack.

Figure -11 and 12 show probable changes in lift and drag as the angle of attack increases. Figure-11 shows effect of angle of attack on Coefficient of Lifts. Hexagonal dimpled airfoil show more lift than a Plain airfoil configuration at corresponding angles of attack. Also hexagonal dimpled model shows uniform increase in lift throughout all angles of attack considered for the study. Figure-12 Also shows variation in coefficient of Drag with respect to angle of attack.Hexagonal dimpled model show decrease in drag than plain airfoil model. The angle of stall also increased in case of hexagonal dimpled airfoil.

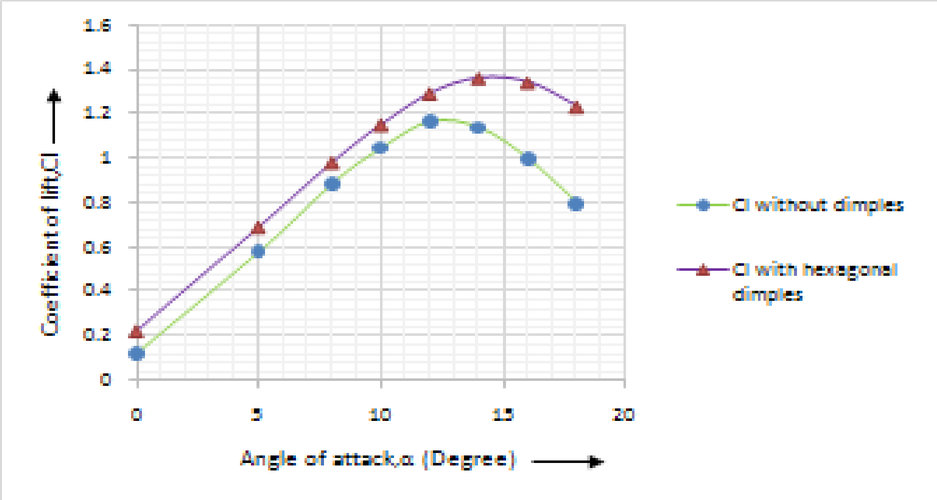

Fig. 11. Coefficient of lift vs Angle of attack

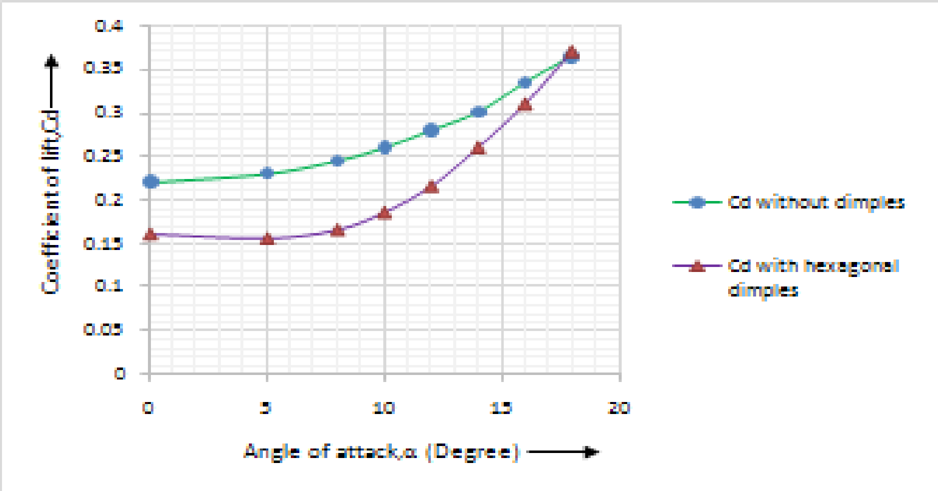

Fig. 12. Coefficient of drag vs Angle of attack

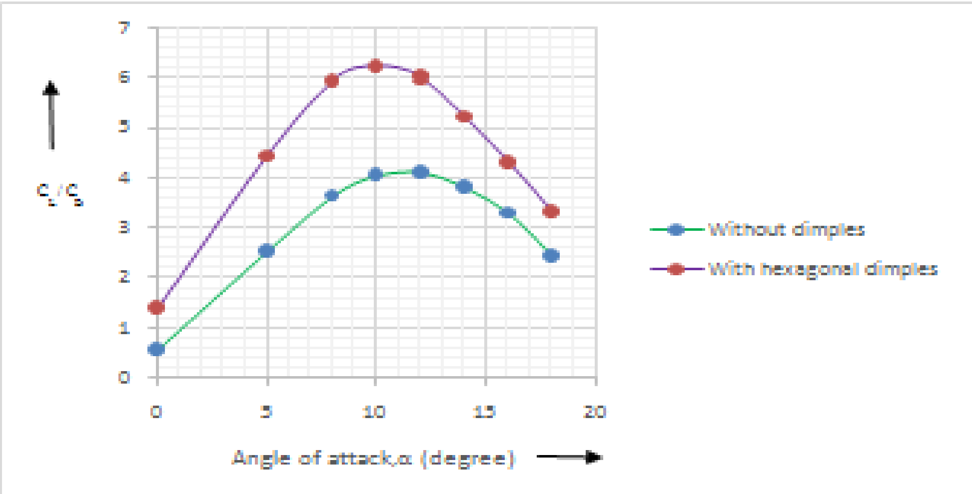

Fig. 13. CL /CD vs Angle of attack

IV. CONCLUSION

From this investigation it has been determined that the flow separation at the surface of the airfoil can be behind schedule by means of the modification with hexagonal dimples at the surface. The connected flow on the dimpled surface is appeared at higher angle of attack than the normal surface. The lift of hexagonal dimpled surface airfoil is greater than the smooth surface. For airfoil with hexagonal dimples about approximately 19.30% increase in lift and approximately 48.39% of reduction in drag as compared to without dimpled airfoil and it is giving wonderful lift/drag ratio. For hexagonal dimpled airfoil there is approximately 53.75% increase in lift to drag ratio.

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