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APPLICATION OF BIOMIMETICS IN DESIGN OF VEHICLES – A REVIEW

AKASH G M

STUDENT, DEPARTMENT OF AEROSPACE ENGINEERING, RV COLLEGE OF ENGINEERING, KARNATAKA, INDIA

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ABSTRACT :- *"LOOK DEEP INTO THE NATURE YOU WILL UNDERSTAND EVERYTHING BETTER"-Albert Einstein Biomimetics plays a vital role in solving complex human problems because the nature is evolving according to its favor (natural selection). This article discusses the various ways that can be implemented in design of the aircraft, automobiles, trains, ships through biomimetics, as engineers are doing lot of research in providing the feasibility of the aerodynamic parameters. Animals and birds are the best natural elements which helps people of this field to improvise, as in this paper we will be discussing about various animals which helped the engineers to ease their work, some of the versatile birds like owl, merganser recently they found one of the migratory bird geese which fly in a "V" shape to save energy and benefit from the "air upwash" of the leader. This flight technique represents a significant opportunity to help airlines to reduce fuel consumption and pollutants like carbon dioxide, kingfisher which helped in improving the speed of the train and box fish where a bionic car is made by the company Mercedes Benz which reduces the drag and shark in designing the ship which also helped in its drag reduction*

KEYWORDS: Trailing edge, Biomimetics, Lift, Drag, Reynolds number, bionic, Wake,

1. INTRODUCTION

Biological organisms have evolved well-adapted structures and materials over geological time through natural selection. Biomimetics is a concept which imitates and inspired by biological solutions at macro and nano scales i.e. humans have looked into the nature for answers to the problems throughout our existence, nature has solved major engineering problems such as self-healing abilities, environmental exposure tolerance and resistance, hydrophobicity, self-assembly, and harnessing solar energy.

Aircraft design and flight techniques are being inspired by birds and bats and box fish for the design of car, shark in the design of ship and the bird kingfisher for designing the nose of the train. Nature has spent millions of years refining. This paper discusses solution for various problems in design of the vehicles which helped to reduce the drag and hence focuses on those designs which have been brought out through "BIOMIMETICS".

2. RESEARCH REVIEW

LIFT ENHANCEMENT BY SETE:

The studies carried out by Tianshu, Williams and Qamar have showed that lift will get enhanced using static extended trailing edge they used this technique by imitating birds like **owl** and **merganser** where zero-lift drag and Ostwald efficiency remains unchanged. They also started analyzing the development of wake flow structures with base line model as well as SETE where the value for base line model was found out to be 0.032 and the value for SETE was lesser than the baseline model that is 0.02, so they came to the conclusion that SETE produced fewer wakes as compared to the base line model and application of SETE can improve the cruise flight efficiency of transport aircraft and UAV without changing the basic aerodynamic configuration.

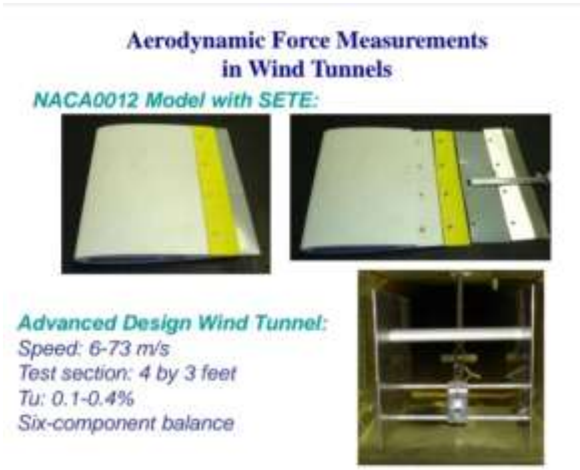


FIG 01 MODEL WITH SETE

FIG 02 SETE OF OWL AND MERGANSER

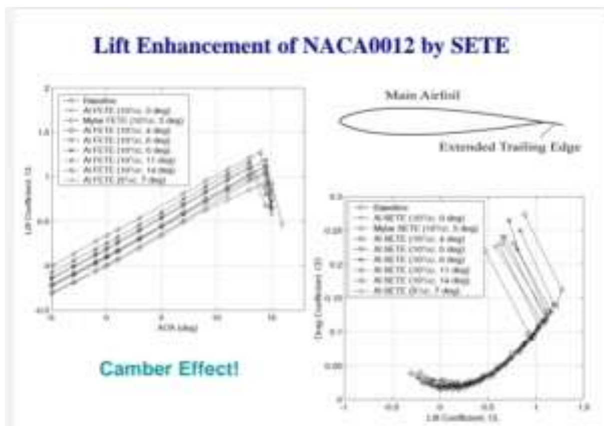


FIG 03 LIFT ENHANCEMENT OF NACA 0012 BY SETE

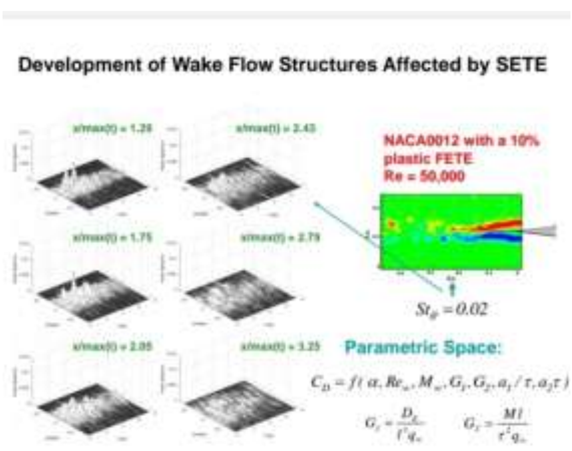


FIG 04 DEVELOPMENT OF WAKE FLOW STRUCTURES AFFECTED BY SETE

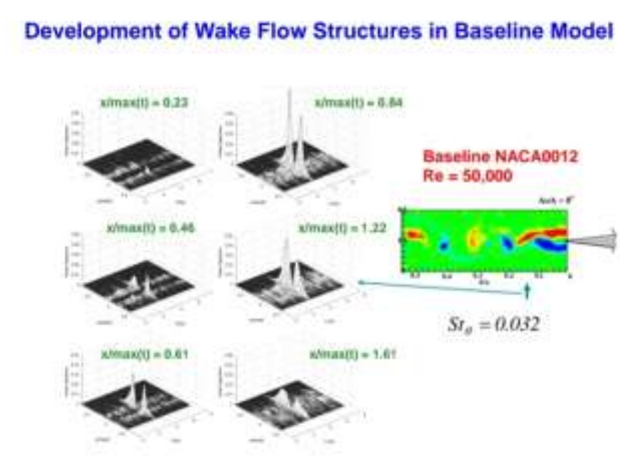
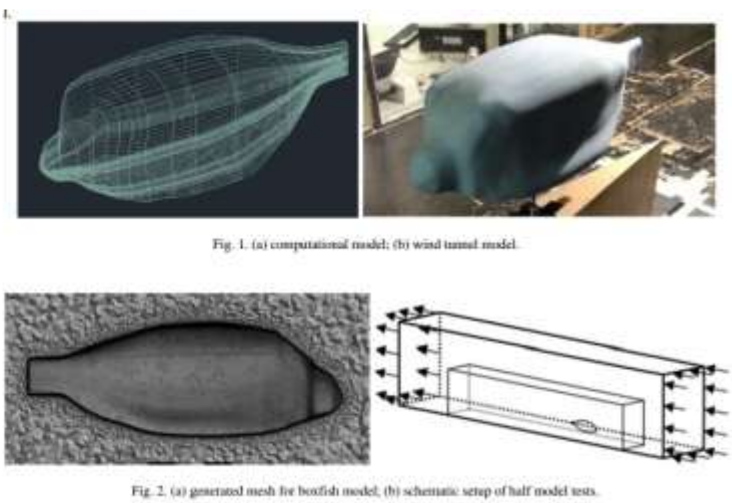


FIG 05 DEVELOPMENT OF WAKE FLOW STRUCTURES IN BASELINE MODEL

3. STUDY OF AERODYNAMICS OF BOX FISH:

This paper investigated on the aerodynamic behavior of a boxfish using both experimental and computational method. A scaled up model boxfish was manufactured and tested in RMIT. For the required wind tunnel data, for experimental study they used RMIT industrial wind tunnel, where the lift and side forces were not determined and presented in this paper. They only presented the data of drag , Apart from numerical data, they also made analysis on flow features around the simplified model and they found that the simplified boxfish model achieves low drag characteristics and they came to the conclusion that together with the wind tunnel data and mesh convergence studies. CFD results have been established and an overall agreement at higher Reynolds number was achieved, the simplified box fish model which they have made displayed a favorable drag coefficient of 0.073 at a Reynolds number equivalent to 100km/h in flow velocity , and boxfish geometry was found to be a very efficient at minimizing the disturbance Mercedes Benz decided to model the Bionic after this fish due to the supposed low coefficient of drag of its body shape and the rigidity of its exoskeleton; which influenced the car's unusual looks.



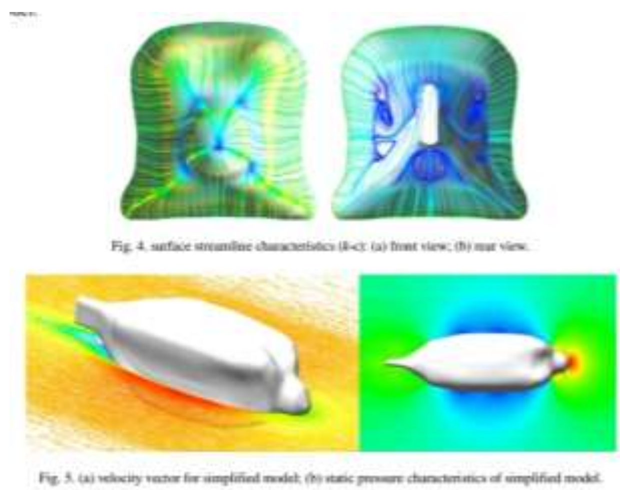
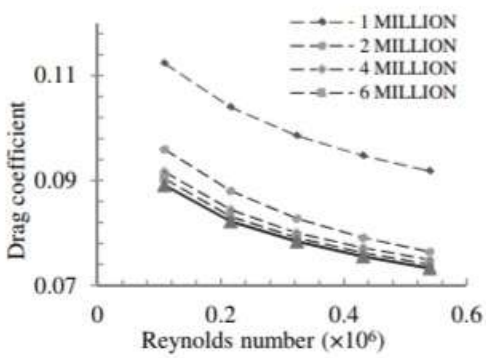
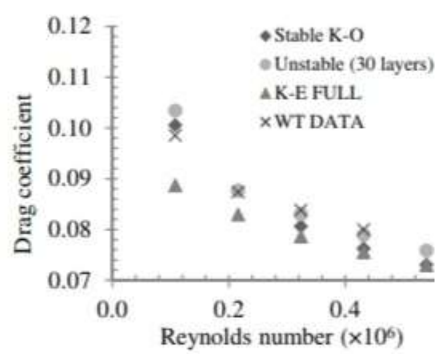


FIG 06 COMPUTATIONAL MODEL AND WIND TUNNEL MODEL SCHEMATIC SETUP OF HALF MODEL TESTS

FIG 07 STREAMLINE CHARACTERISTICS AND VELOCITY VECTOR FOR SIMPLIFIED MODEL





(a) (b)

CHART 01 (a) DRAG COEFFICIENT CONVERGENCE CHARACTERISTICS

(b) DRAG COEFFICIENT VARIATION WITH REYNOLDS NUMBER

4. SHAPE OPTIMIZATION OF HIGH SPEED RAIL BY BIOMIMETICS

This paper discusses on shape optimization of high speed rail by biomimetics, where they checked the aerodynamics of train nose because only nose and tail will play a vital role in giving pressure, to reduce them, they used sharp edges, studied about the micropressure wave, which has been subjected to train nose, calculated different drag for different carriages of CRH380A. They used sailfish which is known as the fastest fish in the ocean, An adult peregrine falcon which is the fasted animal in the world which dives at a speed over 386km/h, A belted kingfisher which could fly at a speed ranged between 58-72 km/h, They also took dolphin which has highly streamlined shape because of it which allows it to sprint. They obtained three key concepts from the animal model , they are types of nose, cross section type and nose shape and the bio models were obtained mainly by combining different key concepts of morphological evaluation , The bio models were obtained mainly by combining different key concepts of morphological evaluation, The bio models were then compared with the relative design of CRH380A as the bench mark of this research and they finally came to the conclusion that the drag coefficient of the high speed rail is not dependent on the cross-section of the train body, neither round based nor square based shows the comparison of drag coefficient for different groups of bio-models ; round based cross section and square based cross section. They totally used 8 bio models named 111,112,121,122,211,212,221,222 in which the drag coefficient 111 and 211 is lower than that of 121 and 221 by 5% while the drag coefficient of 112 and 212 is higher than that of 121 and 222 by 3%. The drag coefficient for rounded nose shape models were higher because the area of stagnation point for rounded nose shape is larger and the impact is greater compared to that of sharp nose shape. The maximum pressure at the nose tip of model 211 is 209pa. However the maximum nose pressure of model 211 is 555pa.There is a huge difference in pressure between the two types of nose shape. Therefore they concluded that sharp nose shape is more efficient than rounded nose shape.

TABLE 01 DRAG COEFFECIENT RESULT

Train model	Published C_D	Simulated C_D	
CRH380A	**0.1971**	**0.1973**	
Bio-model	C_D	Bio-model	C_D
111	0.1582	*211*	0.1559
112	0.1922	*212*	0.1826
121	0.1655	*221*	0.1651
122	0.1845	*222*	0.1785

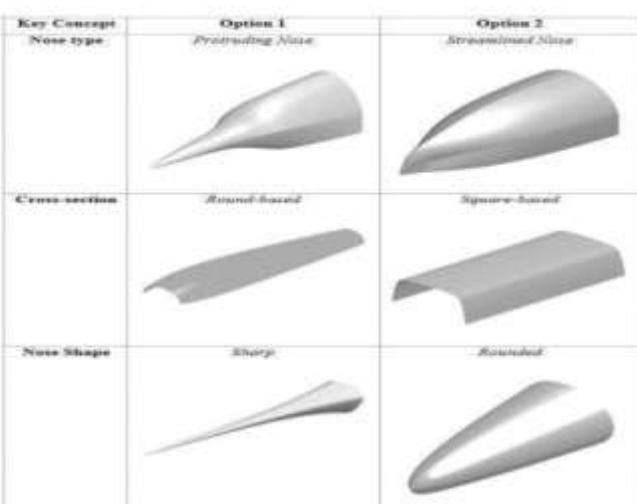


Fig. 5. Morphological chart

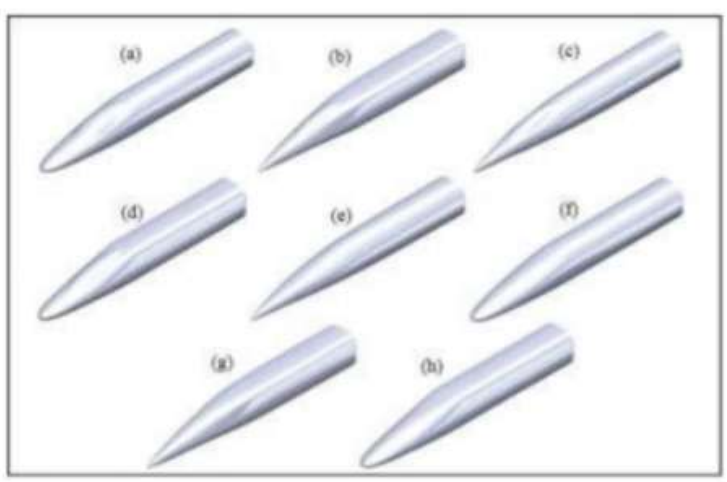


Fig. 6. Bio-models (a) 111, (b) 112, (c) 121, (d) 122, (e) 211, (f) 212, (g) 221, (h) 222.

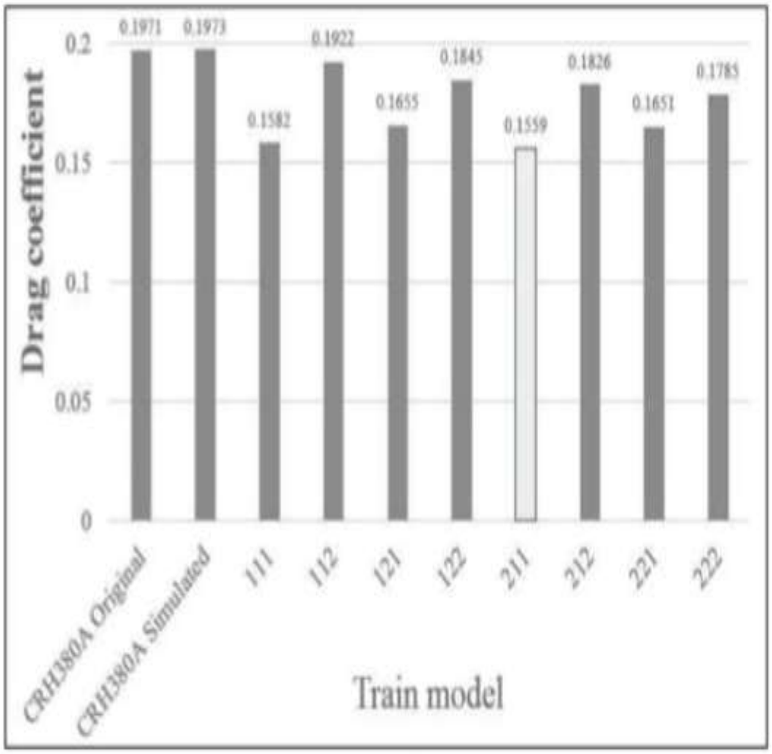


Fig. 8. Drag coefficient of different train models.

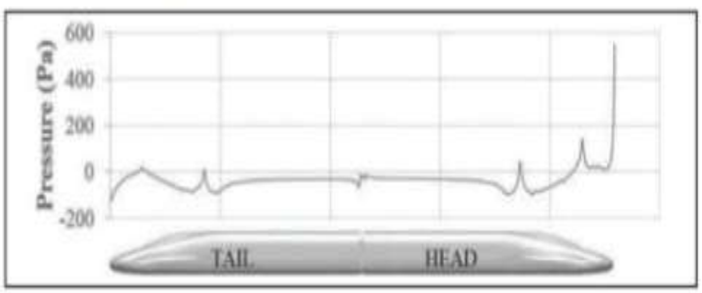


Fig. 9: Pressure distribution of Harmony CRH380A.

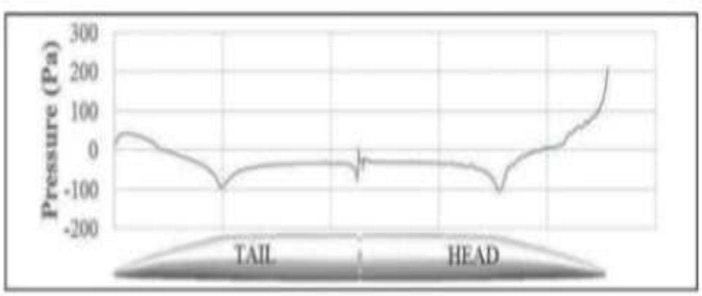


Fig. 10. Pressure distribution of Bio-model 211.

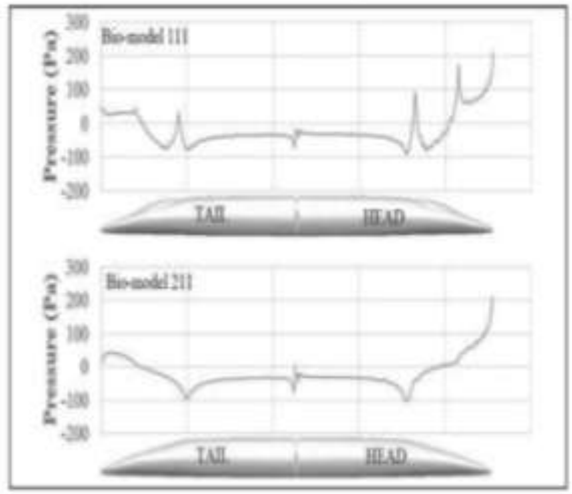


Fig. 11. Pressure distribution comparison of different nose type.

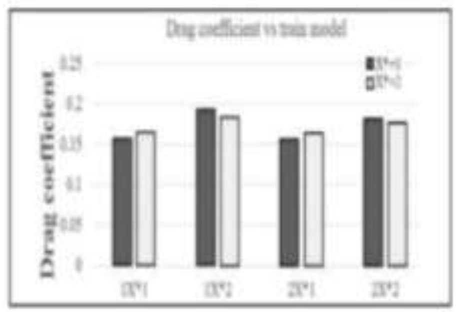


Fig. 12. Drag coefficient of train models with round-based and square-based cross-section.

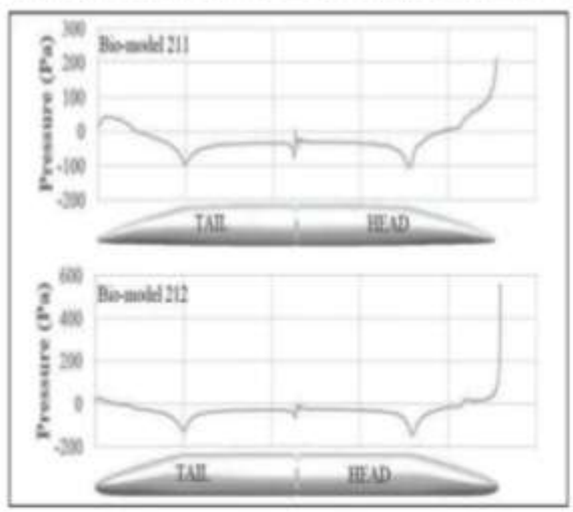


Fig. 13. Pressure distribution comparison of different nose shape.

5. THE STUDY OF DRAG REDUCTION ON SHIPS INSPIRED BY SIMPLIFIED SHARK SKIN IMITATION:

This paper also discusses on drag reduction on ships inspired by simplified shark skin imitation, their main focus was on design modification though bio mimetic riblet structure of shark skin denticle as an attempt in improving the hydrodynamic design of marine vessels in this paper they were mainly focusing on wall shear, velocity profile and turbulence kinetic energy produced by modified and unmodified hull form through CFD activity. Macro scaled biomimetic riblet shark skin is applied on frontal and rear vicinity of the container ship with the intention of improving the fluid flow around the ship which will provide better flow separation control especially at the ship hull surface area and improving performance of system such as ship performance, duct or pump efficiency and saving the energy. It's not easy because of the complex structure of shark skin denticle where the finally concluded that the coefficient of drag has been reduced by 3.75% and gave the reduction of 3.89% in drag force by container ship model.

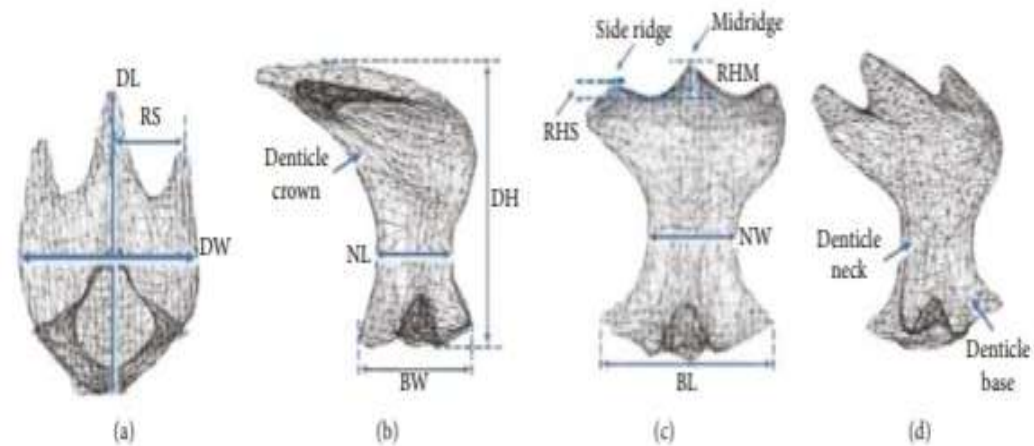


FIG 08 3D reconstructed micro-CT model of a single denticle of mako shark

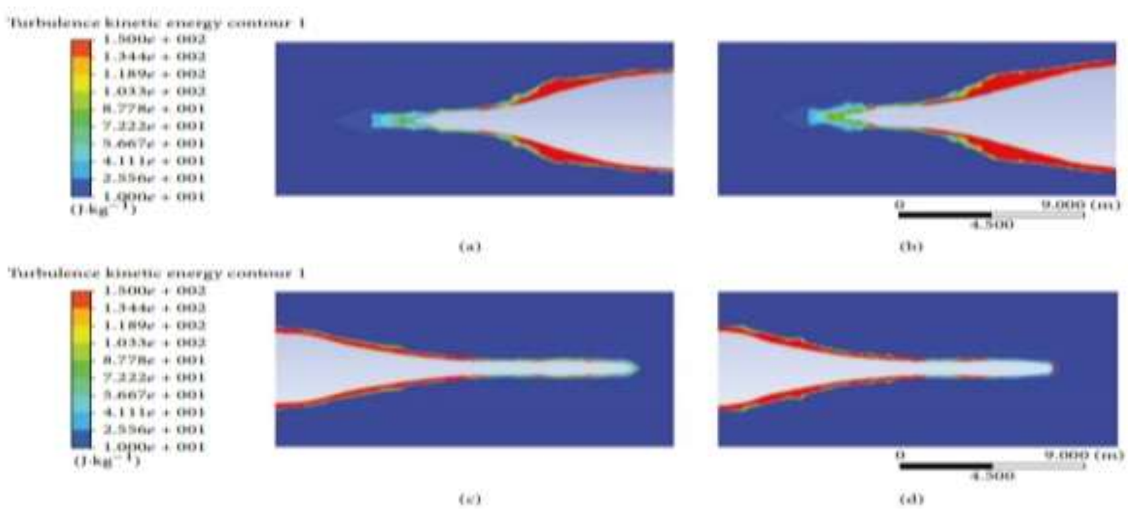


FIG 09 (a) TKE on rear end model of container ship with biomimetic shark skin (b) TKE on rear end model of plain ship (c) TKE on front model of container ship with biomimetic shark skin (d) TKE on front model of plain ship

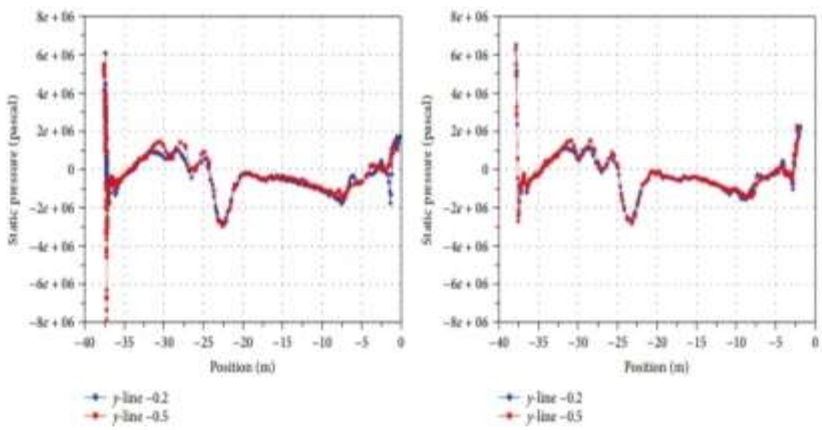


CHART 02 Pressure , Isoline on CS Model with biomimetic shark skin

CONCLUSION:

This review paper mainly focuses on the design of vehicles , which was applied through biomimetics as this paper focused on only few aerodynamic parameters there may be various objectives where we can get solutions for major engineering problems such as fuel consumption, reducing the emission of pollutant gases which harm our nature. As the main goal of today's scenario is to uplift the sustainable development, why only nature has this capacity is because it will evolve itself according to its environment, we can take human as the best example for this which explained how he get evolved himself from animals like lemur from 7,00,00000 years ago to until today, so the main primary objective of this paper is to start looking in the nature for finding the solutions for each and every engineering problems because as everyone knows "CHANGE IS THE LAW OF NATURE" natural elements will be always changing day by day according to its ease the only thing we need to do is understand them and start to save them.

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