International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

Analysis of Submarine with the Study of Mechanical Investigations using Borei - Class Submarine Model

Amit Kumar Mehar
Associate Professor, Mechanical Engineering
Raghu Engineering College (Autonomous)
Andhra Pradesh, India

Potoju Muralidhar
Mechanical Engineering
Raghu Engineering College (Autonomous)
Andhra Pradesh, India

***Abstract*— In this current era of globalization every prosperous country in the world are wishes to develop a high technological machine-like nuclear-powered submarine, long ranging missile equipped submarines etc. To increase their navel strength and force for their countries pride. Even a highly equipped and technologically advanced submarine got damaged due to the collisions with mountain rocks, or ice bergs in ocean / sea. Sometimes these collisions lead to critical damage of parts of submarine, or injuries to soldiers. In this research work, modelling of a Borei – class submarine models are done by using a modelling software, CATIA V5. Various investigations and their analysis done by using ANSYS CFD & ANYSYS Explicit Dynamics By using ANSYS the analyzed parameters are drag force, drag coefficient, lift Force, lift coefficient, deformation, total velocity, total acceleration, equivalent stress, maximum principal stress, minimum principal stress, maximum shear. stress, stress intensity, equivalent strain, maximum principal elastic strain, minimum principal elastic strain, maximum shear elastic strain, elastic strain intensity.**

Keywords*— Borei-class submarine, CATIA, ANSYS, CFD, Explicit Dynamics, Drag, Lift, Deformation, Stress, Strain, Streamlines, Velocity, Acceleration.

INTRODUCTION:

A ship powered by atomic energy is called nuclear submarine that travels primarily under-water, but also on the surface of the ocean. previously conventional submarines used diesel engines that required air for moving on the surface of the water, and battery – powered electric motors for moving beneath it. The limited lifetime of electric batteries meant that even the most advanced conventional submarine could only remain submerged for a few days at slow speed, and only a few hours at top speed. On the other hand, nuclear submarines can remain under-water for several months. This ability, combined with advanced weapons technology, makes nuclear submarines one of the most useful warships ever built. [1-3]

I. SHIP STRUCTURE AND PARTS

A Submarine has Outer hull and inner hull which is made of different material alloys Like Hy80 or Titanium Harden steel, etc. inner hull protects the crew from the water pressure bearing down on the submarine in the outer hull provides a streamlined shape to the submarine.

C. Trim tanks: These are in the front part and aft (rearward) sections of the submarine, which are also able to take on or release water in order to keep the submarine's weight equally distributed.

D. Rudder: These are vertically aligned, to submarine and by moving it, the ship can be directed side-to-side.

E. Stern planes: are horizontally aligned, so that moving them will guide the submarine's movement upward or -downward.

F. Propeller: These powered by the steam-driven turbine and generators. The steam is created by the nuclear reactor.

G. Nuclear Reactor: These are essentially a glorified steam engine. It's usually located in the rear portion of the submarine. The reactor is protected by a thick metal casing that weighs around 100 tons. A specially designed alloy inside this shielding further protects the radioactive fuel rods.

H. Sonar sphere: it is located in the Front part of the submarine. Sonar helps a submarine detect other objects in the water. It works by sending out a sound wave. If this sound wave strikes an object, a portion of the sound will be echoed back to the sub.

I. Torpedo room: is where all torpedoes are stored and loaded into torpedo tubes to prepare them for launching.

J. Mess deck: Forward compartment: submarine's crew is housed and fed in very tight, efficient quarters called the berthing and mess deck. Usually, this area is in the middle level of the ship's forward compartment.

II. NUCLEAR SUBMARINE ATMOSPHERE

Nuclear Powered Submarines is particularly suitable for vessels which need to be at sea for long periods without refueling. In Nuclear Powered Submarines are submariners live and work in an atmosphere composed of approximately 80% naturally occurring nitrogen, 19% oxygen (manufactured aboard ship), and a complex mixture of inorganic and organic contaminants. The concentrations of contaminants exist as a balance between the rates of production from human and operational activities and the rate of removal by engineering systems. The biological effects of inorganic gases, particularly carbon dioxide, have been extensively studied. Investigators are now attempting to define the composition and concentration of volatile organic compounds that accumulate during 90-day submergences. Medical studies have not conclusively shown that crewmembers incur adverse health effects from continuous exposures to the sealed atmospheres of nuclear submarines. In future, constraints on fossil fuel use in transport may bring marine nuclear propulsion into more widespread use. So far, exaggerated fears about safety have caused political restriction on port access [4-9]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

III. BOREI-CLASS SUBMARINE MODEL DESIGN AND ANALYSIS.

Using the CATIA Design software and prepare the Borei – class submarine model.
This Borei – class submarine model was design in Catia and after modelling the submarine it is imported to ANSYS.
In ANSYS There is two types tests are conducted on submarine

A. ANSYS CFD Analysis

B. ANSYS Explicit Dynamics

A. ANSYS CFD Analysis

In this research work CFD analysis done at Borei – class submarine model and find the Pressure Effect, Velocity Effect, Drag force, Drag Coefficient, Lift force, Lift coefficient, Streamlines, Volume Rendering, at Different velocities and compare the different at different velocities 500m/s, 1000m/s, 1500m/s. and find the results of all these parameters effect on the submarine. [10-14]

B. ANSYS Explicit Dynamics

In this research work Explicit Dynamics analysis done at Borei – class submarine model and find the deformation, total velocity, total acceleration, equivalent stress, maximum principal stress, minimum principal stress, maximum shear. [15-17]

IV. ABOUT BOREI-CLASS SUBMARINE:

The new design for this Borei class submarine carries Bulava submarine-launched ballistic missiles. Borei-class submarine was planned to launch in 2009 but due to delay of Bulava development and fitted in 2013. There is lot of failures during test launches by 2017 out of 27 tests 12 were failure Development of missiles continues.

Country of origin	Russia
Entered service	2012
Crew	130 men
Diving depth (operational)	380 m
Diving depth (maximum)	400 - 450 m
Sea endurance	90 - 100 days

Dimensions and displacement

Length	160 m
Beam	13.5 m
Draught	10 m
Surfaced displacement	14 720 tons
Submerged displacement	24 000 tons

Propulsion and speed

Surfaced speed	15 knots
Submerged speed	26 - 29 knots
Propulsion	nuclear reactor and pump jet propulsion

Armament

Missiles	16 x Bulava SLBMs
Torpedoes	6 x 533 mm torpedo tubes

Analysis of Borei-class submarine:

Pressure:
The pressure at 500 m/s, 1000m/s, 1500m/s velocity:

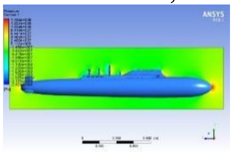


fig: 1 pressure at 500 m/s

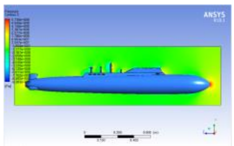


fig: 2 pressure at 1000 m/s

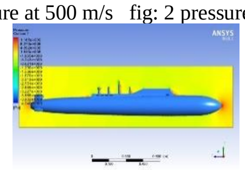


Fig: 3 pressure at 1500m/s

velocity:
velocity effect at 500 m/s,1000m/s,1500m/s.

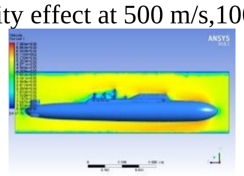


fig: 4 velocity at 500m/s

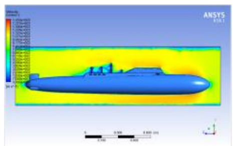


fig: 5 velocity at 1000m/s

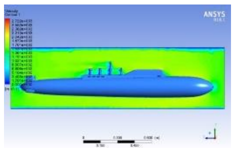


Fig: 6 velocity at 1500m/s

Velocity streamlines
An important concept in the study of hydrodynamics concerns the idea of streamlines. The below figure shows that velocity streamlines at 500m/s striking on the Borei-class submarine model.

Velocity streamlines at 500 m/s,1000m/s, 1500m/s

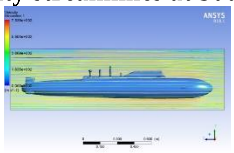


fig: 7 streamlines 500m/s

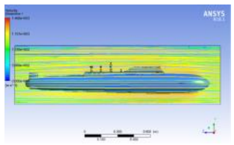


fig: 8 streamlines 1000m/s

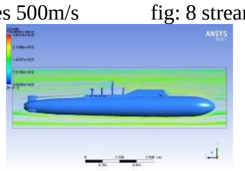
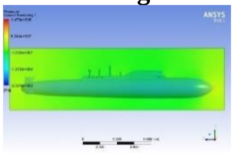


Fig: 9 streamlines 1500m/s

volume rendering
Volume rendering shows that the body Borei-class submarine. The enclosure applied on the body is suitable or not can be visualize in this volume rendering.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

Volume rendering at velocity 500m/s, 1000m/s, 1500m/s



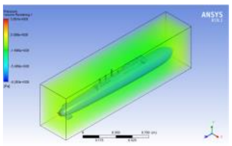


Fig: 10 volume rendering 500m/s Fig: 11 volume rendering at 1000m/s

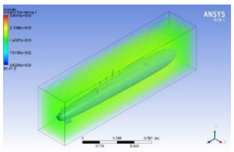
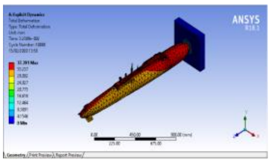


Fig: 12 volume rendering at 1500m/s

I. Explicit Dynamics

Compression with same velocity at 8.09935 knots and same collision time 10000 s with changing fixed supports.

Deformation



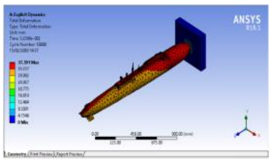


fig 16.Deformation of top fixed supports fig 17.Deformation of both side fixed support

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
3.2389e-002		37.391

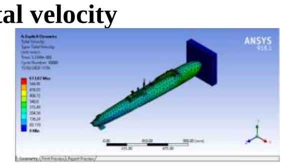
Table **1**

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
3.2389e-002		37.391

Table **2**

The deformation of the submarine analyzed at velocity of 8.09935 knots, found that deformation is independent of fixed supports

Total velocity



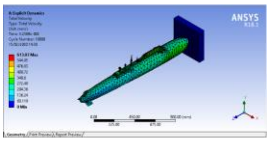


fig 18.Total velocity of Top fixed support fig 19. Total velocity of both side fixed support

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	4166.7
3.2389e-002		613.07

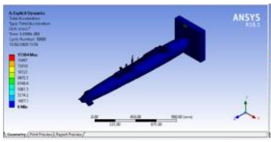
Table **3**

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	4166.7
3.2389e-002		613.07

Table **4**

The total velocity of the submarine analyzed at velocity of 8.09935 knots, found that total velocity is independent of fixed supports

Total acceleration



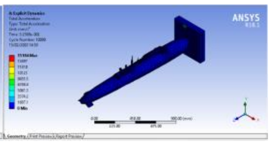


fig 20.Total acceleration of top fixed support fig: 21. Total acceleration of both side fixed support

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
3.2389e-002		15184

Table **5**

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
3.2389e-002		15184

Table **6**

The total acceleration of the submarine analyzed at velocity of 8.09935 knots, found that total acceleration is independent of fixed supports.

Equivalent elastic stress

i.Equivalent stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		17.802

Table 7

ii. Equivalent stress of both side fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		17.802

Table 8

The equivalent stress of the submarine analyzed at velocity of 8.09935 knots, found that equivalent stress is independent of fixed supports

Maximum principal stress

I.Maximum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-0.461	4.5418

Table 9

ii. Maximum principal stress of both side fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-0.461	4.5418

Table 10

The maximum principal stress of the submarine analyzed at velocity of 8.09935 knots, maximum principal stress found that is independent of fixed supports

Minimum principal stress

I. Minimum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-16.03	1.035

Table 5. 11

ii. Minimum principal stress both side fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-16.03	1.035

Table 5. 12

The minimum principal stress of the submarine analyzed at velocity of 8.09935 knots, minimum principal stress found that is independent of fixed supports

Maximum shear stress

I. Maximum shear stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		9.1588

Table 13

i. Maximum shear stress of both side fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		9.1588

Table 14

The maximum shear stress of the submarine analyzed at velocity of 8.09935 knots, maximum shear stress found that is independent of fixed supports

Stress intensity

I.Stress intensityof top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		18.318

Table 5. 15

ii. Stress intensityof both side fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		18.318

Table 5. 16

The stress intensity of the submarine analyzed at a velocity of 8.09935 knots, stress intensity found that is independent of fixed supports

Equivalent elastic strain

i.Equivalent strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002		0.13397

Table 17

ii. Equivalent strain of both side fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002		0.13397

Table 18

The equivalent strain of the submarine analyzed at velocity of 8.09935 knots, found that equivalent strain is independent of fixed supports

Maximum principal elastic strain

I. Maximum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	1.2499e-006	9.5979e-002

Table 5. 19

ii. Maximum principal elastic strain of both side fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	1.2499e-006	9.5979e-002

Table 5. 20

The maximum principal elastic strain of the submarine analyzed at velocity of 8.09935 knots, found that maximum principal elastic strain is independent of fixed supports

Minimum principal elastic strain

i. Minimum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	-8.021e-002	9.5222e-005

Table 21

ii. Minimum principal elastic strain of both side fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	-8.021e-002	9.5222e-005

Table 22

The minimum principal elastic strain of the submarine analyzed at a velocity of 8.09935 knots, found that minimum principal elastic strain is independent of fixed supports.

Maximum shear elastic strain

i.Maximum shear elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 23

ii. Maximum shear elastic strain of both side fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 24

The maximum shear elastic strain of the submarine analyzed at velocity of 8.09935 knots, found that maximum shear elastic strain is independent of fixed supports.

Elastic strain intensity

i. Elastic strain intensity of Top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 25

ii. Elastic strain intensity of both side fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 26

The elastic strain intensity of the submarine analyzed at velocity of 8.09935 knots, found that elastic strain intensity is independent of fixed supports.

Comparing the top fixed support at velocity 8.09935 knots with same velocity changing the fixed supports and increases the collision time from 10000 s to 1000000 s.

Deformation

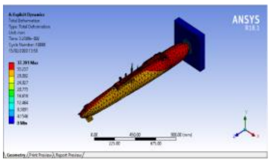


Fig 22.Deformation of Top fixed supports

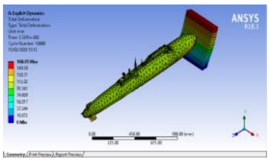


fig 23.Deformation of bottom fixed support

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
3.2389e-002		37.391

Table 27

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
3.3291e-002		168.05

Table 28

The deformation of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that deformation is high compare less collision time

Total velocity

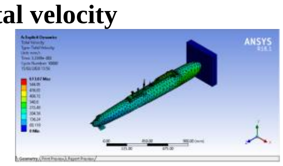


Fig 24.Total velocity of Top fixed support

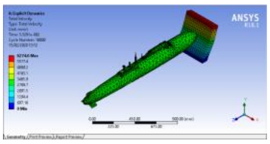


fig 25. Total velocity bottom fixed support

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	4166.7
3.2389e-002		613.07

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	4166.7
3.3291e-002		6274.6

Table 29

Table 30

The total velocity of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that total velocity is high compare to less collision time

Total acceleration

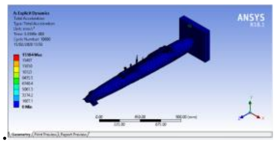


Fig 26.Total acceleration of top fixed support

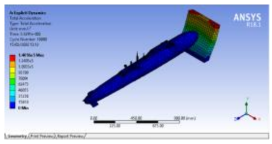


fig 27. Total acceleration of bottom fixed support

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
3.2389e-002		15184

Table 31

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
3.3291e-002		1.4056e+005

Table 32

The total acceleration of the submarine analyzed at velocity of 8.09935 knots and comparing changing the fixed support and with increasing collision time from 10000 s to 1000000 s, found that total acceleration is less compare to less collision time

Equivalent elastic stress

i.Equivalent stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		17.802

Table 33

ii. Equivalent stress of both bottom support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.3291e-002		9.2819

Table 34

The equivalent elastic stress of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that equivalent elastic stress is less compare with less collision time

Maximum principal stress

I.Maximum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-0.461	4.5418

Table 35

ii. Maximum principal stress of bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.3291e-002	-1.6122	4.0823

Table 36

The maximum principal stress of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that maximum principal stress is high compare with less collision time

Minimum principal stress

I.Minimum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-16.03	1.035

Table 37

ii. Minimum principal stress of bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.3291e-002	-9.34	0.75162

Table 38

The minimum principal stress of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that minimum principal stress is low compare with less collision time

Maximum shear stress

I. Maximum shear stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		9.1588

Table 39

ii. Maximum shear stress of bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.3291e-002		4.8786

Table 40

The maximum shear stress of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that maximum shear stress is low compare with less collision time

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

Stress intensity

I.Stress intensityof Top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		18.318

Table 41

ii. Stress intensityof bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.3291e-002		9.7572

Table 42

The stress intensity of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that stress intensity is low compare with less collision time

Equivalent elastic strain

i.Equivalent strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002		0.13397

Table 43

ii. Equivalent strain of bottom support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.3291e-002		0.58765

Table 44

The equivalent elastic strain of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that equivalent elastic strain is high compare with less collision time

Maximum principal elastic strain

I. Maximum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	1.2499e-006	9.5979e-002

Table 45

ii. Maximum principal elastic strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.3291e-002	1.6334e-007	0.67854

Table 46

The maximum principal elastic strain of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time, found that maximum principal elastic strain is high compare with less collision time

Minimum principal elastic strain

i.Minimum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	-8.021e-002	9.5222e-005

Table 47

ii. Minimum principal elastic strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.3291e-002	-4.1222e-002	2.0031e-003

Table 48

The minimum principal elastic strain of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time, found that minimum principal elastic strain is high compare with less collision time

Maximum shear elastic strain

i.Maximum shear elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 49

ii. Maximum shear elastic strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.3291e-002	7.9698e-007	0.70747

Table 50

The maximum shear elastic strain of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that maximum shear elastic strain is high compare with less collision time

Elastic strain intensity

i. Elastic strain intensity of Top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 51

ii. Elastic strain intensity of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.3291e-002	7.9698e-007	0.70747

Table 52

The elastic strain intensity of the submarine analyzed at a velocity of 8.09935 knots and comparing with changing the fixed support and increasing collision time from 10000 s to 1000000 s, found that elastic strain intensity is high compare with less collision time

Comparing the top fixed support at velocity 8.09935 knots with chaining the velocity at 16.1987 knots with bottom fixed support with same collision time 10000 sec.

DEFORMATION

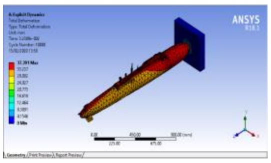


Fig 28.Deformation of Top fixed supports

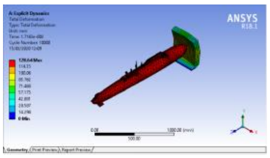


Fig 29.Deformation of Bottom fixed support

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
3.2389e-002		37.391

Table 53

Time [s]	Minimum [mm]	Maximum [mm]
1.1755e-038	0.	0.
1.7163e-002		128.64

Table 54

The deformation of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that deformation is high in 16.1987 in compare to 8.09935.

Total velocity

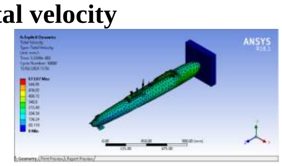


fig 30 total velocity of top fixed support

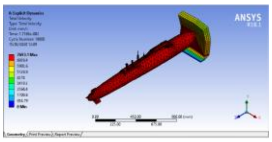


fig 31. Total velocity of bottom fixed support

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	4166.7
3.2389e-002		613.07

Table 55

Time [s]	Minimum [mm/s]	Maximum [mm/s]
1.1755e-038	0.	8333.3
1.7163e-002		7693.1

Table 56

The total velocity of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that total velocity is high in 16.1987 in compare to 8.09935.

Total acceleration

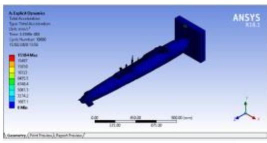


Fig 35.total acceleration of Top fixed support

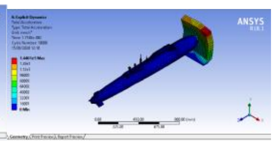


fig 36. Total acceleration of bottom fixed support

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
3.2389e-002		15184

Table 5. 57

Time [s]	Minimum [mm/s²]	Maximum [mm/s²]
1.1755e-038	0.	0.
1.7163e-002		1.4401e+005

Table 5. 58

The total acceleration of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that total acceleration is high in 16.1987 in compare to 8.09935.

Equivalent elastic stress

i.Equivalent stress of Top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		17.802

Table 59

ii. Equivalent stress of bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
1.7163e-002		3.6118

Table 60

The total acceleration of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that total acceleration is low in 16.1987 in compare to 8.09935.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

maximum principal stress

I.maximum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-0.461	4.5418

Table 61

ii. Maximum principal stress of Bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
1.7163e-002	-0.35107	2.9065

Table 62

The maximum principal stress of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that maximum principal stress is low in 16.1987 in compare to 8.09935.

Minimum principal stress

i.Minimum principal stress of top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002	-16.03	1.035

Table 63

ii. Minimum principal stress of bottom fixed suppot

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
1.7163e-002	-2.5876	0.44647

Table 64

The minimum principal stress of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that minimum principal stress is low in 16.1987 in compare to 8.09935.

Maximum shear stress

i. Maximum shear stress of Top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		9.1588

Table 65

ii. Maximum shear stress of bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
1.7163e-002		2.0816

Table 66

The maximum shear stress of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that maximum shear stress is low in 16.1987 in compare to 8.09935.

Stress intensity

I.stress intensityof Top fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
3.2389e-002		18.318

Table 67

ii. Stress intensityof bottom fixed support

Time [s]	Minimum [MPa]	Maximum [MPa]
1.1755e-038	0.	0.
1.7163e-002		4.1632

Table 68

The stress intensity of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that stress intensity is low in 16.1987 in compare to 8.09935.

Equivalent elastic strain

i.Equivalent strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002		0.13397

Table 69

ii. Equivalent strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
1.7163e-002		1.5166

Table 70

The equivalent elastic strain of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that equivalent elastic strain is high in 16.1987 in compare to 8.09935.

Maximum principal elastic strain

i. Maximum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	1.2499e-006	9.5979e-002

Table 71

ii. Maximum principal elastic strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
1.7163e-002	2.4682e-007	1.3162

Table 72

The maximum principal elastic strain of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that maximum principal elastic strain is high in 16.1987 in compare to 8.09935.

Minimum principal elastic strain

i.Minimum principal elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	-8.021e-002	9.5222e-005

Table 73

ii. Minimum principal elastic strain of bottom support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
1.7163e-002	-0.76894	3.0546e-004

Table 74

The minimum principal elastic strain of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that minimum principal elastic strain is high in 16.1987 in compare to 8.09935.

Maximum shear elastic strain

i.maximum shear elastic strain of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 75

ii. Maximum shear elastic strain of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
1.7163e-002	1.8032e-006	2.038

Table 76

The maximum shear elastic strain of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that maximum shear elastic strain is high in 16.1987 in compare to 8.09935.

Elastic strain intensity

i. Elastic strain intensity of top fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
3.2389e-002	8.516e-006	0.16484

Table 77

ii. Elastic strain intensity of bottom fixed support

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.1755e-038	0.	0.
1.7163e-002	1.8032e-006	2.038

Table 78

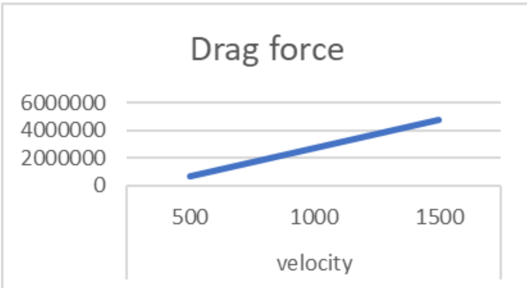
The elastic strain intensity of the submarine analyzed at velocity of 8.09935 knots and comparing with changing the fixed support and increasing the velocity to 16.1987, found that elastic strain intensity is high in 16.1987 in compare to 8.09935.

The Below tables show the Drag force along the velocities 500, 1000, 1500 at different velocities for Titanium alloy. From the table it is observed that the increasing in the velocity will leads to increase in the Drag Force of the Submarine. And drag coefficient is also increases

Drag force along the velocities of 500, 1000, 1500.

	velocity		
	500	1000	1500
Drag force	681705.1	2724829	4795526

Table 79



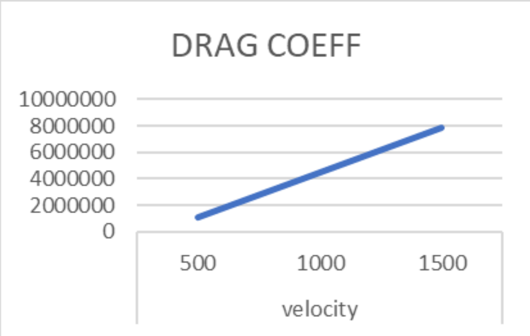
Graph 1 Drag force

Drag Coefficient along the velocities of 500, 1000, 1500.

	velocity		
	500	1000	1500
DRAG COEFF	1112988	4448701	7829431

Table 80

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

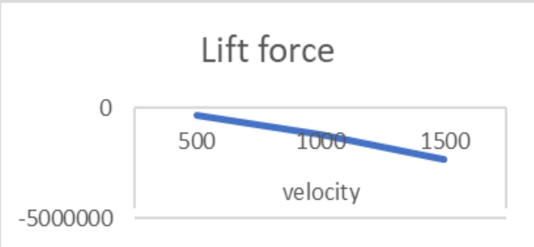


Graph 2 Drag coefficient

Lift Force along the velocities of 500, 1000, 1500.

	velocity		
	500	1000	1500
Lift force	-307278	-1227523	-2337382

Table 81

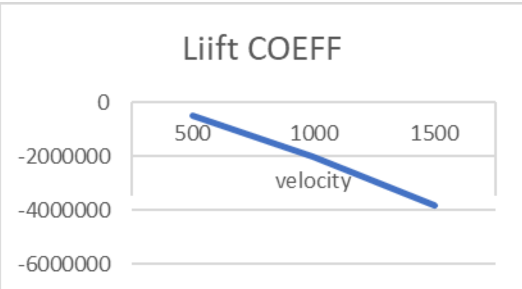


Graph 3 Lift coefficient

Lift Coefficient along the velocities of 500, 1000, 1500.

	velocity		
	500	1000	1500
Lift COEFF	-501516	-2004120	-3816134

Table 82



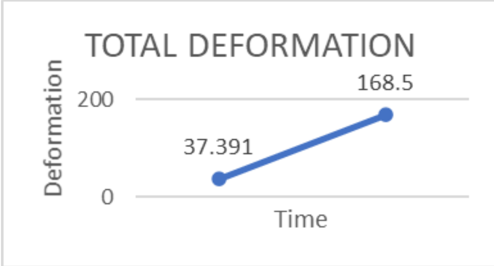
Graph 4 Lift coefficient

In this research the blow tables show the deformations and velocities and accelerations and stress, strains and shows the changes of the occurs on the submarine. In this research we did this compression between changed the Fixed supports with same velocities and increasing the collision time.

Total Deformation

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
37.391	168.5

Table 83

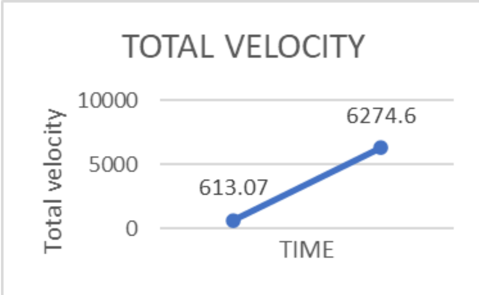


Graph 5 Deformation

6.6 Total Velocity

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
613.07	6274.6

Table 84

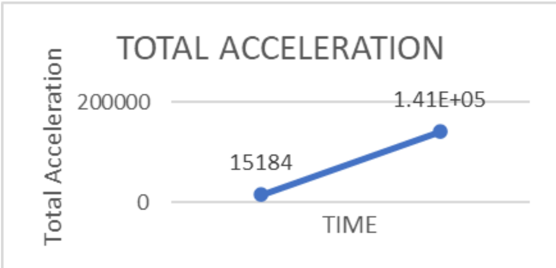


Graph 6 Time vs velocity
(Top vs bottom supports) Total velocity

Total Acceleration

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
15184	1.41E+05

Table 85

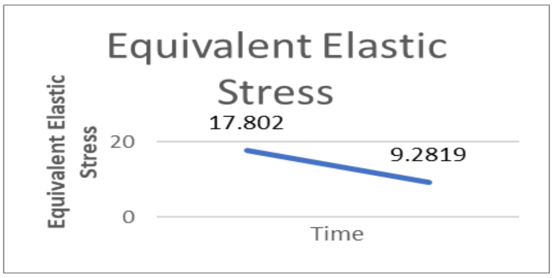


Graph 7 Time vs velocity
(Top vs bottom supports) Total acceleration

Equivalent Elastic Stress

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
17.802	9.2819

Table 86



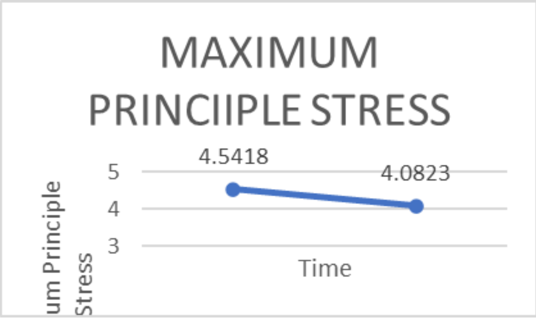
Graph 8 Time vs velocity
(Top vs bottom supports) Equivalent elastic stress

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

Maximum principle stress

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
4.5418	4.0823

Table 87

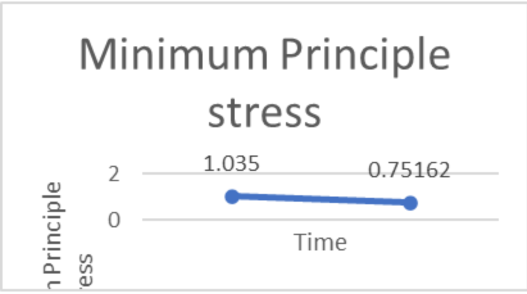


Graph 9 Time vs velocity
(Top vs bottom supports) Maximum principle Stress

Minimum Principle Stress

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
1.035	0.75162

Table 88

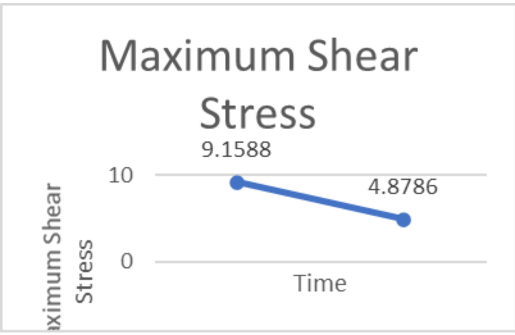


Graph 10 Time vs velocity (Top vs bottom supports)
Minimum principle stress

Maximum Shear Stress

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
9.1588	4.8786

Table 89

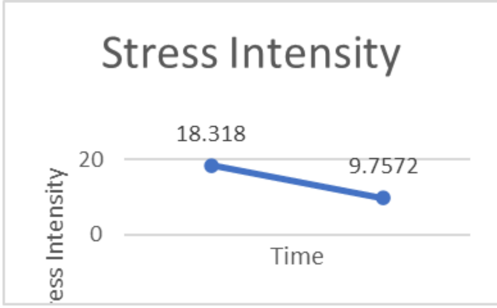


Graph 11 Time vs velocity (Top vs bottom supports)
Maximum shear stress

Stress Intensity

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
18.318	9.7572

Table 90

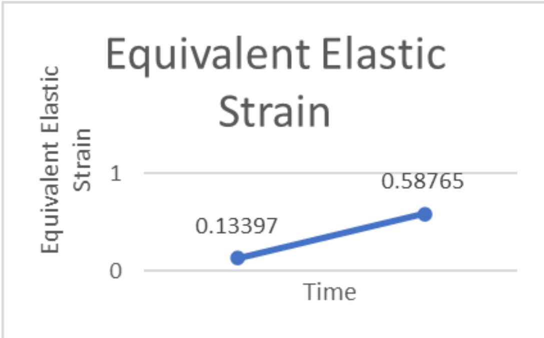


Graph 12 Time vs velocity
(Top vs bottom supports) Stress intensity

Equivalent Elastic Strain

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
0.13397	0.58765

Table 91

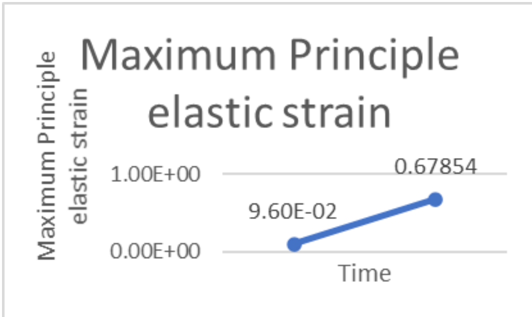


Graph 13(Time vs velocity (Top vs bottom supports)
Equivalent elastic strain

Maximum Principle Elastic Strain

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
9.60E-02	0.67854

Table 92

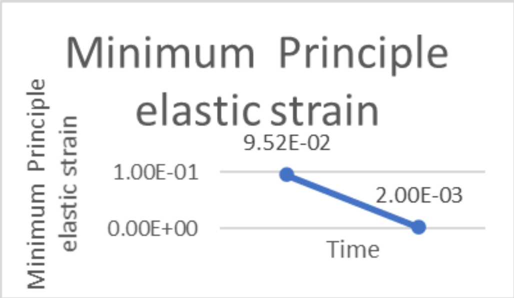


Graph 14 Time vs velocity (Top vs bottom supports)
Maximum principle elastic strain

Minimum Principle Elastic Strain

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
9.52E-02	2.00E-03

Table 93

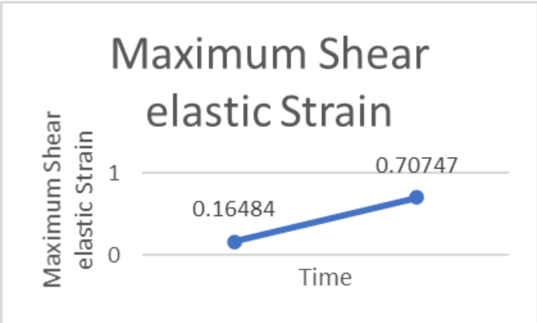


Graph 15 Time vs velocity (Top vs bottom supports) Minimum principle elastic

Maximum Shear Elastic Strain

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
0.16484	0.70747

Table 94

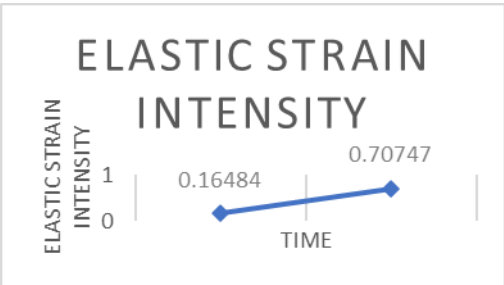


Graph 16 Time vs velocity (Top vs bottom supports) Maximum shear elastic strain

Elastic Strain Intensity

TOP SUPPORT (max time)	BOTTOM SUPPORT (max time)
3.2390E-02	3.3291E-02
0.16484	0.70747

Table 95



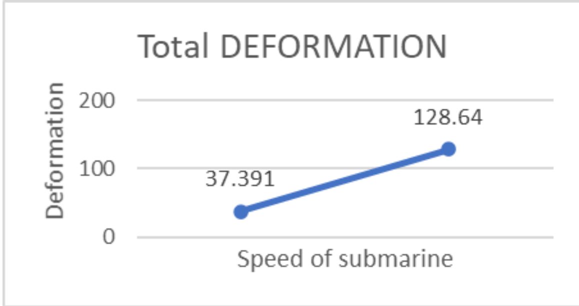
Graph 17 Time vs velocity (Top vs bottom supports) Elastic strain intensity

In this research the blow tables show the deformations and velocities and accelerations and stress, strains and shows the changes of the occurs on the submarine. In this research we did this compression between changed the Fixed supports with changed the velocities and increasing the collision time.

Total Deformation

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
37.391	128.64

Table 96

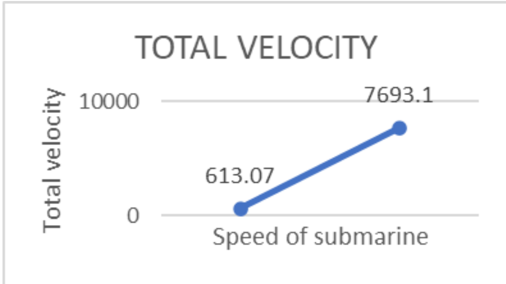


Graph 18 Time vs velocity (Top vs bottom supports) Total deformation

Total Velocity

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
613.07	7693.1

Table 97

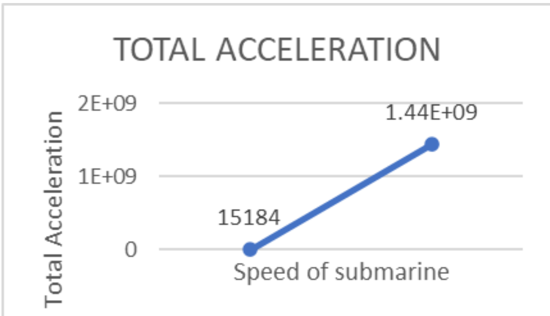


Graph 19 Time vs velocity (Top vs bottom supports) Total velocity

6.20 Total Acceleration

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
15184	1.44E+09

Table 98



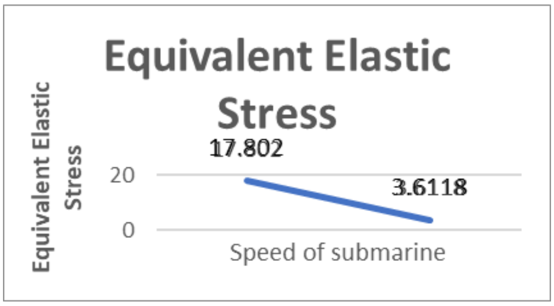
Graph 20 Time vs velocity (Top vs bottom supports) Total acceleration

Equivalent Elastic Stress

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
17.802	3.6118

Table 99

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

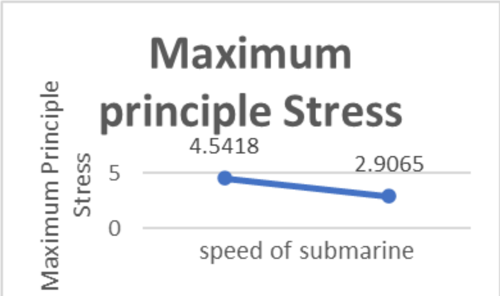


Graph 21 Time vs velocity (Top vs bottom supports) Equivalent elastic stress

Maximum Elastic Stress

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
4.5418	2.9065

Table 100

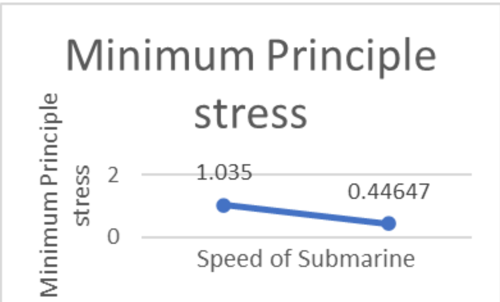


Graph 22 Time vs velocity (Top vs bottom supports) maximum Principle stress

Minimum Principle Stress

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
1.035	0.44647

Table 101



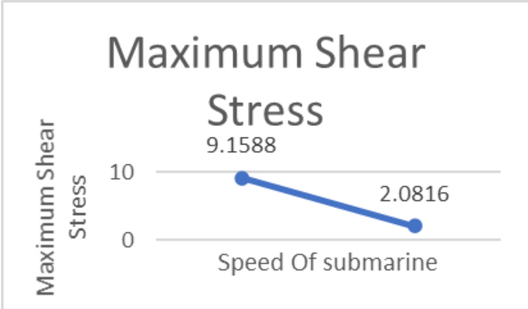
Graph 23 Time vs velocity (Top vs bottom supports) Minimum principle stress

Maximum Shear Stress

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
9.1588	2.0816

Table 102

Time vs Velocity different fixed supports

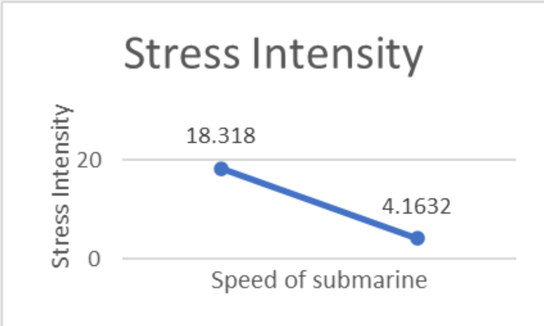


Graph 24 Time vs velocity (Top vs bottom supports) Maximum shear stress

Stress Intensity

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
18.318	4.1632

Table 103

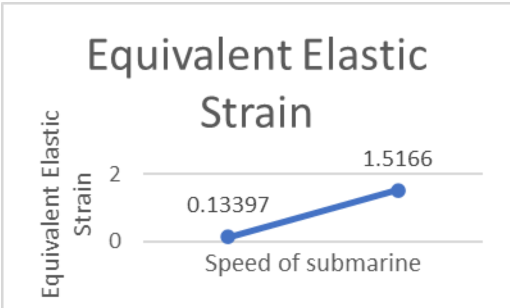


Graph 25 Time vs velocity (Top vs bottom supports) Stress intensity

6.26 Equivalent Elastic Strain

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
0.13397	1.5166

Table 104



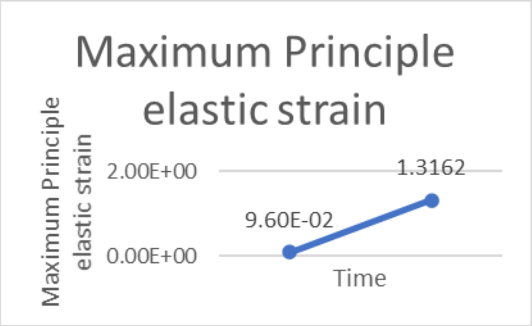
Graph 26 Time vs velocity (Top vs bottom supports) Equivalent elastic strain

Maximum Principle Elastic Strain

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
9.60E-02	1.3162

Table 105

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

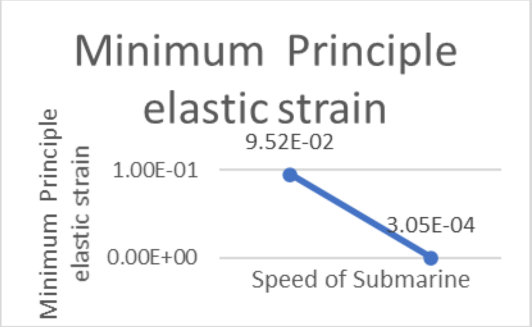


Graph 27 Time vs velocity (Top vs bottom supports) maximum principle elastic strain

Minimum Principle Elastic Strain

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
9.52E-02	3.05E-04

Table 106

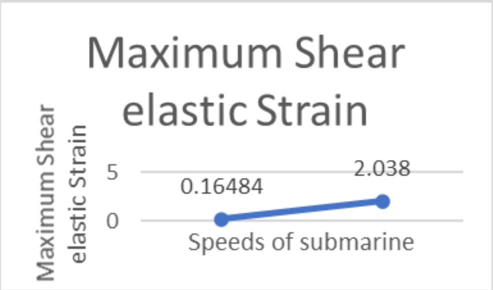


Graph 28 Time vs velocity (Top vs bottom supports) minimum principle

Maximum Shear Elastic Strain

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
0.16484	2.038

Table 107

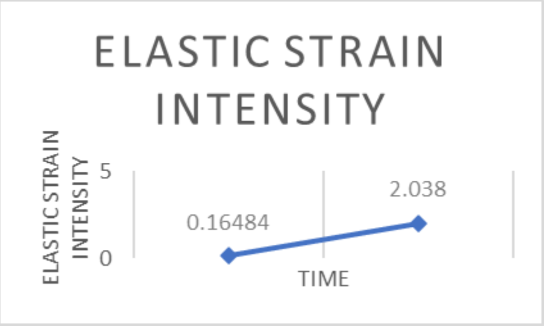


Graph 29 Time vs velocity (Top vs bottom supports) maximum shear elastic strain

Elastic Strain Intensity

TOP SUPPORT	BOTTOM SUPPORT
8.09935 knots	16.1987 knots
0.16484	2.038

Table 108



Graph 30 Time vs velocity (Top vs bottom supports) Elastic strain intensity

CONCLUSION

It is observed that when submarine collision test with some object in under water with a velocity the deformations and stress and strain which are occurred on submarine and find the drag and lift on the submarine.

In this research work of Computational Fluid Dynamics, the Drag force and drag coefficient, is gradually increases when the velocities are increases from 500 to 1500, Lift coefficient and lift force is decreasing when the velocity increases from 500 to 1500.

Using explicit dynamics the collision test did on the submarine with the velocity of 8.09935(15kmph) knots with variable fixed supports of both top and bottom supports and only top fixed support and collision time is same(**10000 s**), and found that there is no change in deformations, velocities, accelerations, Equivalent stress, maximum principal stress, minimum principal stress, stress intensity, Equivalent elastic strain, maximum principal elastic strain, minimum principal elastic strain, maximum shear elastic strain, strain intensity There is No effect on submarine with changing the fixed support.

Due to that we compare that submarine collision test with velocity (8.09935 Knots) and compare with top fixed support and bottom fixed support and increasing collision time (**time from 10000 s to 1000000 s**) the Total Deformation and Total velocity also increases but acceleration decreases. In stress we found Equivalent stress, minimum principal stress, stress intensity is same, but the maximum principal stress is increased. In strains we found Equivalent elastic strain, maximum principal elastic strain, minimum principal elastic strain, maximum shear elastic strain, strain intensity all strains are high compared to previous collision time.

When we compare this collision test with changing the velocity from 8.09935 knots to 16.1987 knots with bottom fixed support with collision time(**10000 s**) the deformations, velocities and accelerations are high compared to the 15kmph and in the stress we found equivalent stress, maximum principal stress, minimum principal stress, stress intensity all are low compared to the 8.09935 knots speed collision. In strains we found Equivalent elastic strain, maximum principal elastic strain, minimum principal elastic strain, maximum shear elastic strain, strain intensity all strains are high compare to 8.09935 knots.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

REFERENCE:

[1] Malcolm J. Smitha, Tom Macadamb and John R. MacKaya 2014, Integrated modelling, design and analysis of submarine structures.
[2] Khairul Ala, Tapabrata Ray and Sreenatha G. Anavatti 2013, Design and construction of an autonomous underwater vehicle
[3] Tomislav ŠABALJA, Ivo SENJANOVIĆ, Neven HADŽIĆ, structural design of a typhoon class submarine
[4] Mark C. Bettle a, Andrew G. Gerber a, George D. Watt b 2009 Unsteady analysis of the six DOF motion of a buoyantly rising submarine
[5] ADITYA CHIVATE, SAURABH KHUJE, SHUBHAM VINCHURKAR, ANUJIT DAFLE, 2018, design and optimization of an underwater vessel for speed augmentation using CFD
[6] A. Vali, B. Saranjam and R. Kamali, 2018 Experimental and Numerical Study of a Submarine and Propeller Behaviors in Submergence and Surface Conditions
[7] K. Jaswanth, B. Geeta Chandra Sekhar, R.Vara Prasad, Flow and Crash Analysis of an F-16 Aircraft Using ANSYS
[8] Douglas R. Knight, Donald V. Tappan, Jeffry S. Bowman, Hugh J. O Neil and S.M. Gordon, 1989, Submarine atmospheres
[9] M. N. Norwooda and R. S. Dowb, 2012, Dynamic analysis of ship structures
[10] Mohammad Moonesun, Yuri Mikhailovich Korol, Hosein Dalayeli, 2015, CFD Analysis on the Bare Hull Form of Submarines for Minimizing the Resistance
[11] M. Moonesun Y.M. Korol and A. Brazhko 2015 CFD analysis on the equations of submarine stern shape
[12] Mohammad Moonesun, Yuri Mikhailovich Korol, Valeri A Nikrasov, Alexander Ursalov, Anna Brajhko, 2016
CFD Analysis of the bow shapes of submarines
[13] Mohammad Monesun, Mehran javidi, pejman charmdooz & karol uri Mikhailovich, 2013 CFD analysis of the bow shapes of submarines
[14] G. Dubbioso, R. Broglia, S. Zaghi, 2016 CFD analysis of turning abilities of a submarine model
[15] Gita Marina Ahadyanti, Wasis Dwi Aryawan, and Muhamad Fyan Dinggi, 2017, Submerged resistance analysis of mini submarine using computational fluid dynamics
[16] Suman Kar, D.G. Sarangdhar & G.S. Chopra, Analyses of ship structures using Ansys
[17] Jeong-Hoon Song, Patrick Lea, and Jay Oswald, 2013, Explicit Dynamic Finite Element Method for Predicting Implosion/Explosion Induced Failure of Shell Structures