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Design and structural analysis of the missile motor body, using Catia & Ansys.

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ABSTRACT

The main function of a missile is transferring of the warhead to the target and this is performed by the means of the thrust produced by the motor body. The project mainly deals with the design and structural analysis of the missile motor body, using Catia & Ansys.

A missile mainly consists of motor body and warhead, the motor body is made of maraging steel, Al-alloy, Ti alloy. And the motor mainly consists of motor body, propellant, igniter & nozzle. The propellant is burnt in the motor body, thus producing high pressurized gases.

The motor body is to be designed such that it withstands very high pressures. By using the material data and studying the properties of the three different alloys to obtain design specifications. The objective is to design motor body for missile application by taking inputs from propellant design and performing structural analysis by determining the stress developed inside the motor case due to propellant burning.

1. INTRODUCTION

A missile is a self-propelled guided weapon system. Missiles have four system components : targeting and/or guidance, flight system, engine, and warhead.

Guidance systems

Missiles may be targeted in a number of ways. The most common method is to use some form of radiation, such as infrared, lasers or radio waves, to guide the missile onto its target. This radiation may emanate from the target (such as the heat of an engine or the radio waves from an enemy radar), it may be provided by the missile itself (such as a radar) or it may be provided by a friendly third party (such as the radar of the launch vehicle/platform, or a laser designator operated by friendly infantry).

Targeting systems

Another method is to target the missile by knowing the location of the target, and using a guidance system such as INS, TERCOM or GPS. This guidance system guides the missile by knowing the missile's current position and the position of the target, and then calculating a course between them. This job can also be performed somewhat crudely by a human operator who can see the target and the missile, and guides it using either cable or radio based remote-control, or by an automatic system that can simultaneously track the target and the missile.

Flight system

Whether a guided missile uses a targeting system, a guidance system or both, it needs a flight system. The flight system uses the data from the targeting or guidance system to maneuver the missile in flight, allowing it to counter inaccuracies in the missile or to follow a moving target. There are two main systems: vectored thrust (for missiles that are powered throughout the guidance phase of their flight) and aerodynamic maneuvering (wings, fins, canards, etc.). Engine

Missiles are powered by an engine, generally either a type of rocket or jet engine. Rockets are generally of the solid fuel type for ease of maintenance and fast deployment, although some larger ballistic missiles use liquid fuel rockets. Jet engines are generally used in cruise missiles, most commonly of the turbojet type, due to its relative simplicity and low frontal area. Turbofans and ramjets are the only other common forms of jet engine propulsion, although any type of engine could theoretically be used.

Warhead
Missiles generally have one or more explosive warheads, although other weapon types may also be used. The warhead or warheads of a missile provides its primary destructive power (many missiles have extensive secondary destructive power due to the high kinetic energy of the weapon and unburnt fuel that may be on board). Warheads are most commonly of the high explosive type, often employing shaped charges to exploit the accuracy of a guided weapon to destroy hardened targets.

Motor body:
Propulsion is the means of providing power to accelerate the rocket body and sustain if necessary, to reach the required target. The basis for the working of rocket propulsion system is well known NEWTON'S laws of motion.

The propulsion of a rocket is achieved with the help of rocket engine. It produces thrust by ejecting very hot gases which are liberated due to the combustion of the propellant. The hot gases are produced in the combustion chamber of the rocket engine by chemical reactions. The propellant is exhausted through a nozzle with high pressure.

2 DESIGNING
Design is the creation of a plan or convention for the construction of an object or a system (as in architectural blueprints, engineering drawing, business process, circuit diagrams and sewing patterns). In some cases the direct construction of an object (as in pottery, engineering, management, and cowboy coding graphic design) is also considered as design.

More formally design has been defined as follows:
A specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to constraint: To create a design, in an environment (where the designer operates)

Another definition for design is a roadmap or a strategic approach for someone to achieve a unique expectation. It defines the specifications, plans, parameters, costs, activities, processes and how and what to do within legal, political, social, environmental, safety and economic constraints in achieving that objective.

Systems engineering:
CATIA offers a solution to model complex and intelligent products through the systems engineering approach. It covers the requirements definition, the systems architecture, the behavior modeling and the virtual product or embedded software generation. CATIA can be customized via application programming interfaces (API). CATIA V5 & V6 can be adapted using Visual Basic and C++ programming languages via CAA (Component Application Architecture); a component object model (COM)-like interface.

Although later versions of CATIA V4 implemented NURBS, V4 principally used piecewise polynomial surfaces. CATIA V4 uses a non-manifold solid engine. CATIA V5 features a parametric solid/surface-based package which uses NURBS as the core surface representation and has several workbenches that provide KBE support.

V5 can work with other applications, including Enovia, Smarteam, and various CAE Analysis applications.

Industries:
CATIA can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/ENGINEER, NX (formerly Unigraphics), and Solid Works are the dominant systems.

Aerospace:
The Boeing Company used CATIA V3 to develop its 777 airliner, and used CATIA V5 for the 787 series aircraft. They have employed the full range of Dassault

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Systems' 3D PLM products — CATIA, DELMIA, and ENOVIA LCA — supplemented by Boeing developed applications.

The development of the Indian Light Combat Aircraft has been using CATIA V5.

Chinese Xian JH-7A is the first aircraft developed by CATIA V5, when the design was completed on September 26, 2000.

Canadian aircraft maker Bombardier Aerospace has done all of its aircraft design on CATIA.

The Brazilian aircraft company, EMBRAER, use CATIA V4 and V5 to build all airplanes.

The Anglo/Italian Helicopter company, Agusta Westland, use CATIA V4 and V5 to design their full range of aircraft.

The Euro fighter Typhoon has been designed using both CATIA V4 and V5.

The main supplier of helicopters to the U.S Military forces, Sikorsky Aircraft Corp., uses CATIA as well.

Bell Helicopter, the creator of the Bell Boeing V-22 Osprey, has used CATIA V4, V5, and now V6.

Automotive:

Many automotive companies use CATIA to varying degrees, including BMW, Porsche, Daimler AG, Chrysler, Honda, Audi, Jaguar Land Rover, Volkswagen, SEAT, Skoda, Bentley Motors Limited, Volvo, Fiat, Banterer International, PSA Peugeot Citroën, Renault, Toyota, Ford, Scania, Hyundai, Škoda Auto, Tesla Motors, Valmet Automotive, Proton, Elba, Tata motors and Mahindra & Mahindra Limited. Goodyear uses it in making tires for automotive and aerospace and also uses a customized CATIA for its design and development. Many automotive companies use CATIA for car structures — door beams, IP supports, bumper beams, roof rails, side rails, body components — because CATIA is very good in surface creation and Computer representation of surfaces. Bombardier Transportation, Canada is using this software to design its entire fleet of Train engines and coaches.

GEOMENTRY AND PROCEDURE USED IN OUR MODELLING:

VARIOUS DESIGNS USED IN CATIA:

(a) Part design
(b) Sketcher or workbench
(c) Assembly

Part design:

It is the detailed design where the geometry is given and we make it as constrained using the different tools in it. They are:

1. Sketch tools
2. profile \
3. Operation
4. Constraint

Sketcher or Workbench:

After completion of geometry and constraints in part design is enters into the workbench to turn the design into the 3D model.

Here the tools which are used are:

1. Sketch based features
2. Dress-up feature
3. Transformation features

Assemble:

Often we use this option , like for example if we want to design a aircraft , so we design each part of an aircraft in separate workbenches and we assemble all the parts in assembly design with all constraints.

Here the toolbars used are:

1. Product structure toolbar
2. Move toolbar
3. Constraint toolbar.

Designing of missile motor body:

Geometric Parameters of missile motor body

Diameter of motor body D1	=	89mm
Diameter of motor body d2	=	86mm

Length of the motor body L* = 244.7mm

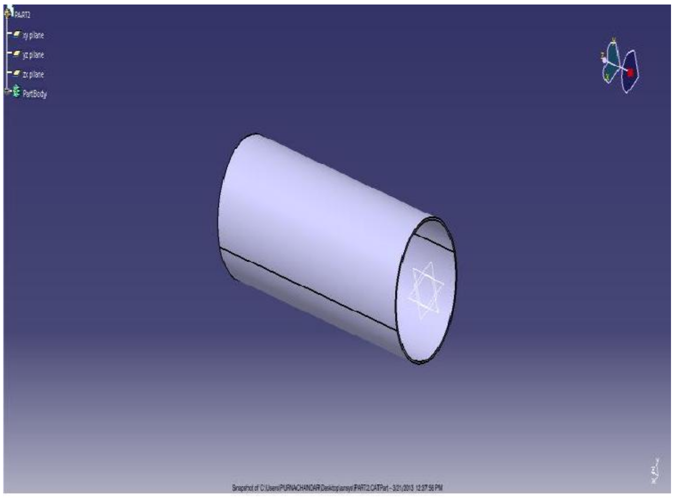
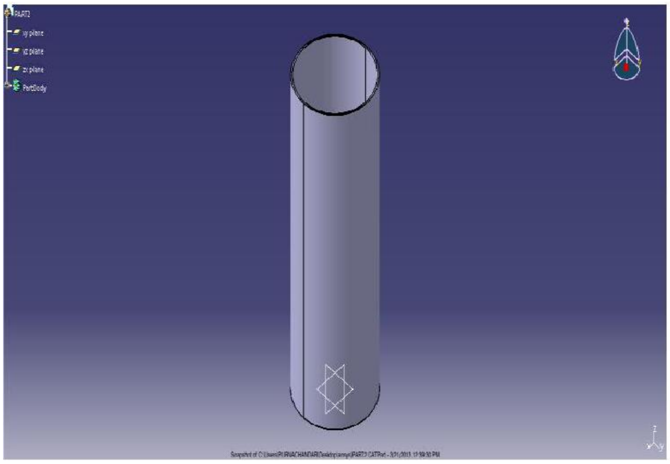
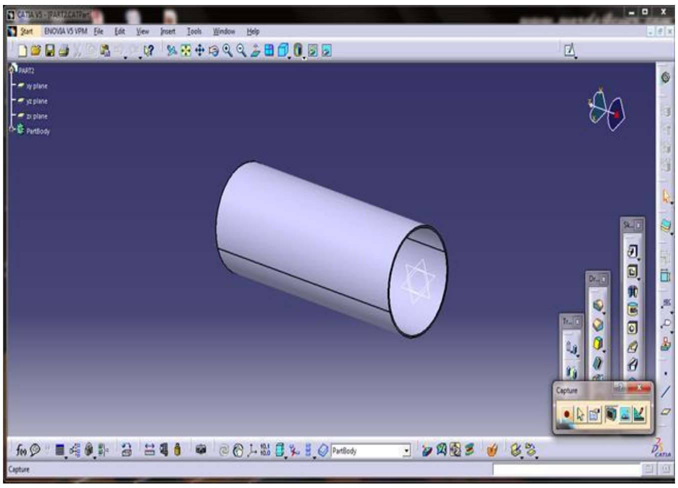


Fig. Motor body





3 ANALYSIS

Steps involved in ANSYS:

Various stages in finite element analysis:

1. Preprocessing:

(a). Create model geometry.
(b). Define material properties.
(c). Choose element type.
(d). Define geometric constraints.
(e). General finite element mesh.

2. SOLUTION:

(a). Apply boundary conditions.
(b). Apply loads.
(c). Solve for unknowns.

3. POST PROCESSING:

(a). Review results like displacements, stress, reactions.
(b). Check validity of solution.

Structural analysis of missile motor body

Structural strength of the body depends upon the material of the body or thickness of the body. The structural strength varies with the properties of the material like Young's modulus, passion's ratio, density, load or pressure applied on the body.
This project is deals with the structural strength analysis of the missile motor body will change with different materials.

There we are analyzed missile motor body based on two materials i.e., Ti alloy, maraging steel and 15CDV6.

Material	**Young's modulus (KN/mm^2)**	**Poisson's ratio**	**UTS (kgf/mm^2)**	**Density (gm/cc)**
Ti alloy	1.138	0.342	100	4.42
Maraging steel	1.9	0.33	185	8
15CDV6	2.0	0.3	100	7.8

Table. Material Properties:

The pressure applied on the missile motor body is P=19.37N/mm^2

The results of these analyses are:

Ti alloy:

Deformation:

Maximum absolute values of motor body deformation.

	Ux	Uy	Uz	Usum
node	9052	11555	14021	9073
value	0.20589	0.20133	-0.18850e-01	0.20616

Table. Deformation of motor body

Ti alloy:

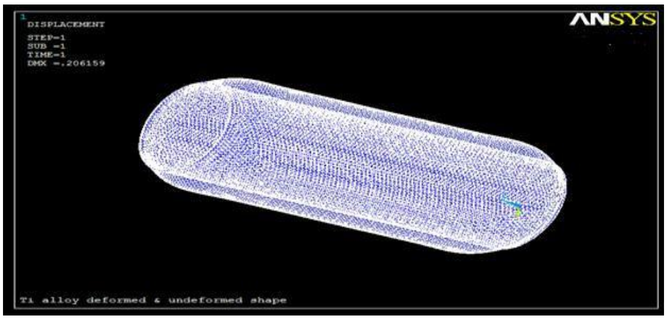


Fig. Deformed and undeformed shape

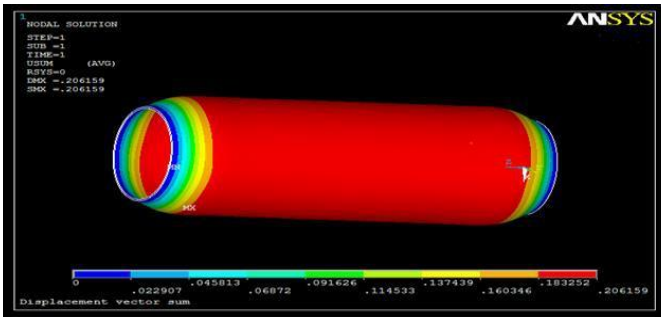


Fig. Displacement vector sum

Stresses on the missile motor body by using Ti alloy are

MINIMUM VALUES

	Sx	Sy	Sz	Sxy	Syz	Sxz
NODE	742	718	189	11458	190	189
VALUE	-114.61	-114.42	-217.83	-290.27	-230.98	-231.05

MAXIMUM VALUES

	Sx	Sy	Sz	Sxy	Syz	Sxz
NODE	11693	8993	17173	11519	50	186
VALUE	600.10	599.12	473.80	290.36	231.15	202.38

MINIMUM VALUES

	S_1	S_2	S_3	S_{int}	Seqv
NODE	4916	189	189	458	458
VALUE	-38.497	-114.00	-402.58	61.449	55.357

MAXIMUM VALUES

	S_1	S_2	S_3	S_{int}	Seqv
NODE	15760	6081	17173	13693	9793
VALUE	614.57	273.60	180.52	586.36	524.81

Strains of the missile motor body by using the Ti alloy

MINIMUM VALUES

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	9814	13195	18308	24451	589	14
VALUE	-0.12168E-02	-0.11938E-02	-0.10084E-02	-0.40448E-02	-0.27010E-02	-0.28962E-02

MAXIMUM VALUES

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	44436	21882	281	46031	487	536
VALUE	0.29176E-02	0.28835E-02	0.27423E-02	0.40332E-02	0.27014E-02	0.28984E-02

MINIMUM VALUES

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	4916	189	189	458	458
VALUE	-38.497	-114.00	-402.58	61.449	55.357

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MAXIMUM VALUES

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	15760	6081	17173	13693	9793
VALUE	614.57	273.60	180.52	586.36	524.81

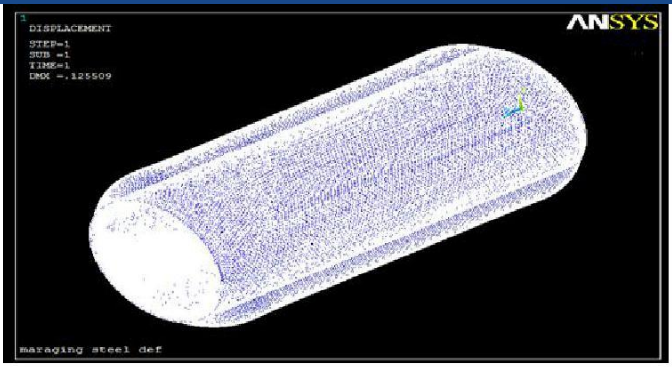

Fig. Deformed and undeformed shape

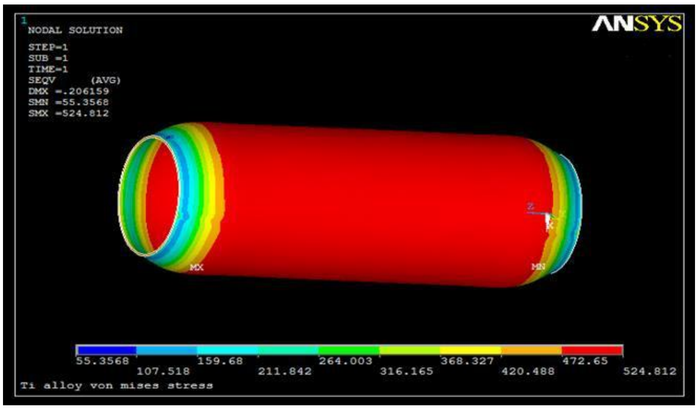

Fig. Von mises stress

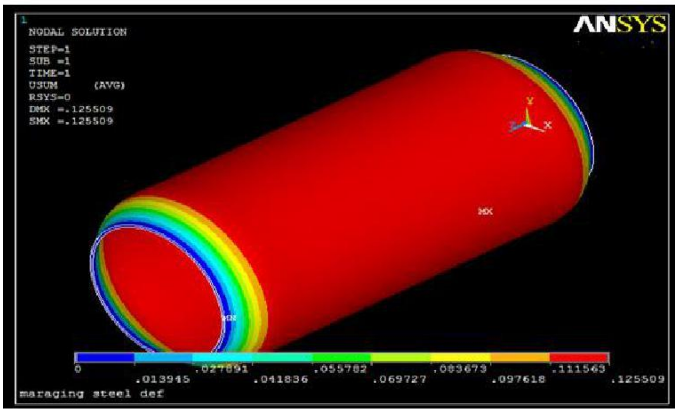

Fig. Displacement vector sum

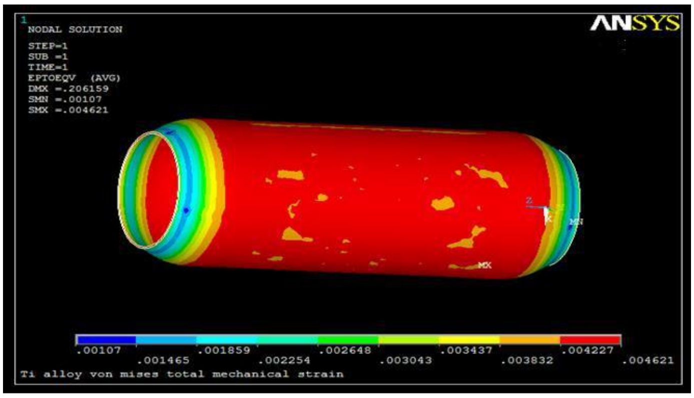

Fig. Von mises total mechanical strain

15CDV6:

Deformation of missile motor body by using 15cdv6:

MAXIMUM ABSOLUTE VALUES:

	UX	UY	UZ	USUM
NODE	38601	60493	6088	38602
VALUE	-1.9826	3.0456	-0.23550	3.6294

Stress on missile motor body by using 15CDV6:

MINIMUM VALUES

NODE	SX	SY	SZ	SXY	SYZ	SXZ
NODE	59026	12508	1346	13602	1116	12328
VALUE	-2468.3	-2047.5	-3711.1	-867.51	-2687.3	-771.41

MAXIMUM VALUES

	SX	SY	SZ	SXY	SYZ	SXZ
NODE	37382	4514	9941	13972	909	12953
VALUE	2502.4	2018.7	3710.9	903.87	2703.3	774.26

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MINIMUM VALUES:

	S_1	S_2	S_3	S_{int}	Seqv
NODE	12498	13684	1443	8426	16868
VALUE	-734.72	-1638.8	-4381.0	88.472	80.182

MAXIMUM VALUES:

	S_1	S_2	S_3	S_{int}	Seqv
NODE	9939	5002	10014	909	909
VALUE	4381.7	1624.8	671.94	5410.3	4685.5

Strain on the missile motor body by using 15CDV6:
MINIMUM VALUES:

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	59026	37358	1445	13602	1116	12328
VALUE	-0.94858E-02	-0.85650E-02	-0.15175E-01	-0.11278E-01	-0.34936E-01	-0.10028E-01

MAXIMUM VALUES:

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	37382	59002	9941	13972	909	12953
VALUE	0.96507E-02	0.85306E-02	0.15193E-01	0.11750E-01	0.35143E-01	0.10065E-01

MINIMUM VALUES

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	8273	15193	1426	8426	956
VALUE	-0.41068E-04	-0.46061E-02	-0.20071E-01	0.57507E-03	0.13542E-02

MAXIMUM VALUES

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	10021	6523	16868	909	909
VALUE	0.20069E-01	0.45552E-02	0.95702E-05	0.35167E-01	0.23564E-01

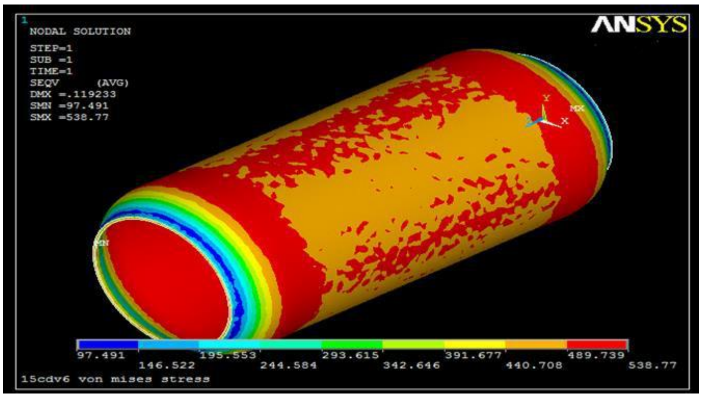

Fig. Von mises stress

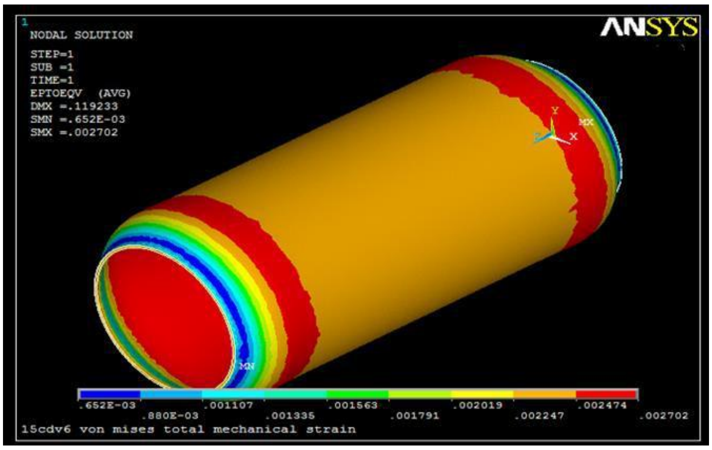

Fig. Von mises total mechanical strai

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Maraging Steel:

Deformation of the missile motor body by using Maraging Steel:

MAXIMUM ABSOLUTE VALUES:

	UX	UY	UZ	USUM
NODE	1109	44338	41294	44340
VALUE	0.12479	-0.12538	0.11278E-01	0.12551

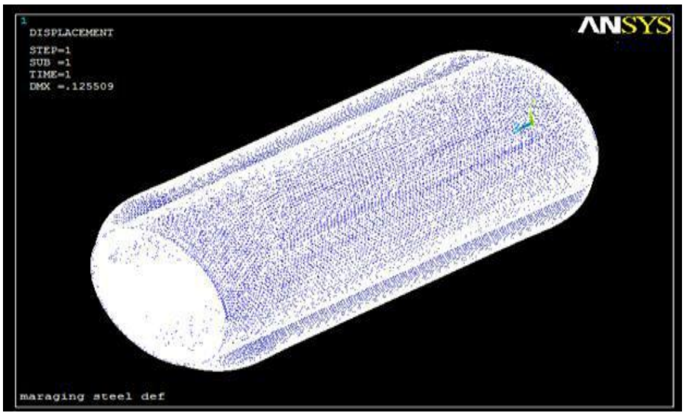

Fig. Deformed and undeformed shape

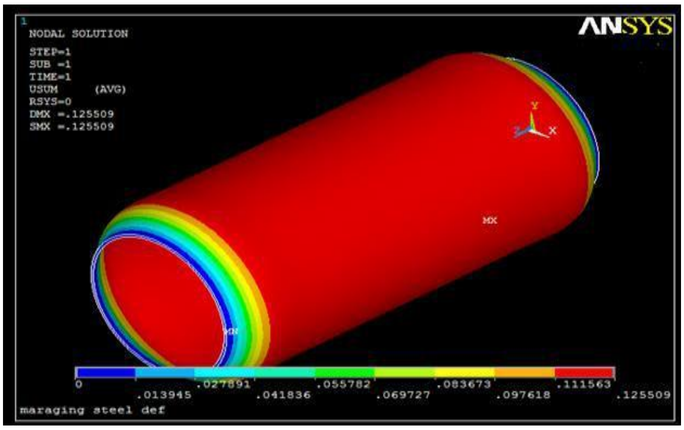

Fig. Displacement vector sum

Stress on missile motor body by using maraging steel

MINIMUM VALUES:

NO	SX	SY	SZ	SXY	SYZ	SXZ
NODE	9712	1458	18308	24451	589	14
VALUE	-100.67	-97.563	-244.22	-295.58	-197.38	-211.65

MAXIMUM VALUES:

	SX	SY	SZ	SXY	SYZ	SXZ
NODE	45061	44162	281	46031	487	536
VALUE	605.59	601.87	700.43	294.74	197.41	211.81

MINIMUM VALUES:

	S_1	S_2	S_3	S_{int}	Seqv
NODE	9712	9712	146	1228	1228
VALUE	-72.280	-103.04	-299.17	110.78	97.491

MAXIMUM VALUES:

	S_1	S_2	S_3	S_{int}	Seqv
NODE	281	281	281	45420	23137
VALUE	747.02	302.93	248.48	593.82	538.77

Strain on the missile motor body by using maraging steel:

MINIMUM VALUES:

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	9814	13195	18308	24451	589	14
VALUE	-0.12168E-02	-0.11938E-02	-0.10084E-02	-0.40448E-02	-0.27010E-02	-0.28962E-02

MAXIMUM VALUES:

	EPTOX	EPTOY	EPTOZ	EPTOXY	EPTOYZ	EPTOXZ
NODE	44436	21882	281	46031	487	536
VALUE	0.29176E-02	0.28835E-02	0.27423E-02	0.40332E-02	0.27014E-02	0.28984E-02

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MINIMUM VALUES:

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	9713	20930	146	1228	10277
VALUE	0.72524E-04	-0.56040E-03	-0.16240E-02	0.75796E-03	0.68610E-03

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MAXIMUM VALUES:

	EPTO1	EPTO2	EPTO3	EPTOINT	EPTOEQV
NODE	485	19195	795	45420	23137
VALUE	0.30693E-02	0.85069E-03	-0.33421E-03	0.40629E-02	0.28445E-02

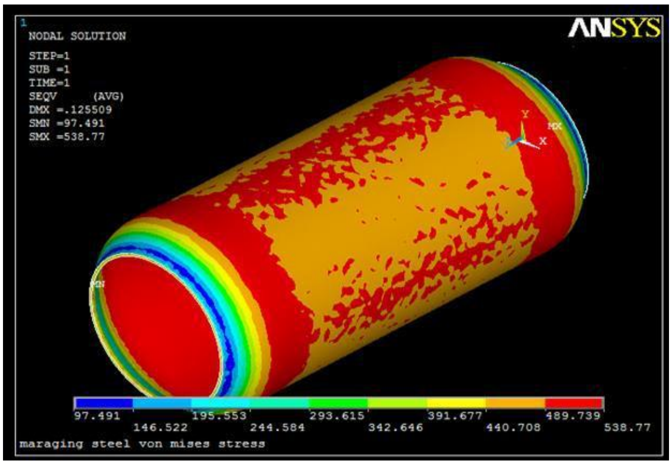


Fig. Von mises stress

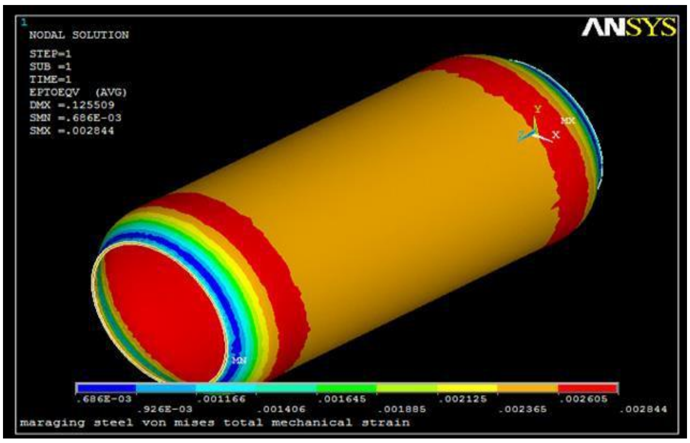
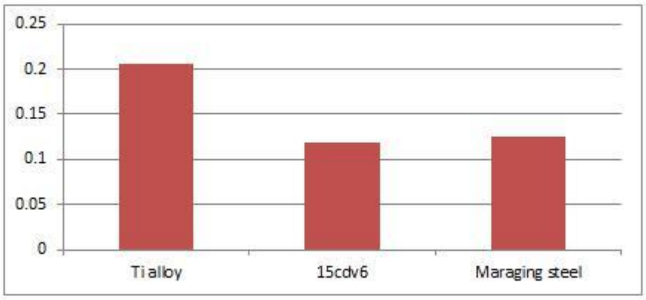


Fig. Von mises total mechanical strain

Results:

Deformations:

Ti alloy	0.206159
15CDV6	0.119233
Maraging steel	0.125509



Stress:

material	Stress
Ti alloy	524.812
15CDV6	538.77
Maraging steel	538.75

4. CONCLUSION

In this project we have studied about the missiles, designed missile motor body and performed structural analysis on missile motor body by using Catia and Ansys. And we showed the comparison over three materials that Ti alloy, Maraging steel and 15CDV6.

From the comparisions it is concluded that-

Titanium alloys are metals which contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing.

1.7734 high performance steel also known as 15CDV6**.** 1.7734 is a high strength easily wieldable steel that can be welded with no risk of cracking or weld weakness without pre or post weld heat treatment in the fully heat treated condition. This makes it ideal for more complicated structures.

Maraging steels are steels (iron alloys) which are known for possessing superior strength and toughness without losing malleability, although they cannot hold a good cutting edge. *Aging* refers to the extended heat-treatment process.

But Ti alloy having low density than maraging steel and 15CDV66, But Ti alloy having more deformation than other two materials. Hence we propose that maraging steel or 15CDV6 has better application than other material.

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