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Modelling and Analysis on Intercontinental Ballistic Missiles Using CATIA and ANSYS

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ABSTRACT

By this study, the structural analysis of design of a ballistic missile which weather it suitable for the launching purpose with changing the fins of the ballistic missile. By the structural view they can vary the pressure under the control of before the missile is ready to blast. The key difficulties in developing semi-trailer structures are to minimize weight, increase strength, and increase stiffness. The design and optimization are presented in this publication. construction of a semi-trailer chassis for a lightweight missile transporter. Up to 40 tones of cargo are supported by the semi-trailer. Three generic missiles with a typical length of up to 12.5 m make up the payload.

The center of gravity of the entire system was raised by stacking these missiles. The semi-ability trailer's to man over safely was geo paradise by its high center of gravity. To satisfy the payload's functional and installation needs, the design process underwent a number of changes. The structure was simulated using a finite element model with regard to the loading circumstances. The model was then put into practice to create an optimization problem.

Key Words: Range, Speed, Warheads, Guidance, Variants, Threats, Design, Analysis, Explicit Dynamics, CFD analysis, CATIA V5, ANSYS

INTRODUCTION

Several trailer configurations and types can deal with the progression of the road regulations governing the size and capacity of trailers. These configurations bear with different forms and quantities of payloads. The trailer types can be classified into two categories either by construction or by the application. The trailer construction may be a full-trailer or semi-trailer. A full trailer is pulled and coupled by a prime mover using a hook or a drawbar. It has axles at the front and rear ends. It doesn't need the prime mover or the landing legs to support it while parking. It has an excellent steering capability thanks to the front axle (or axles). A semi-trailer is similar to a full trailer, but it has an axle (or axles) at the rear end only, and the front axle (or axles) is replaced with a kingpin near the front end.

Computational Fluid Dynamics

Partial differential equations that express the conservation laws for mass, momentum, and energy control the movement of fluids (gases and liquids). Theart of substituting such PDE systems with a set of algebraic equations that can be solved by digital computers is known as computational fluid dynamics.

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Through the use of mathematical models (partial differential equations), numerical techniques (discretization and solution techniques), and software tools, computational fluid dynamics offers a qualitative (and occasionally even quantitative) prediction of fluid flows (solvers, pre- and post-processing utilities) CFD makes it possible for engineers and scientists to conduct "numerical experiments" in a "virtual flow laboratory." When compared to conventional (experimental) methods, CFD provides insight into flow patterns that are difficult, expensive or impossible to analysis. The history of Computational Fluid Dynamics, or CFD for short,, started in the early 1970's. Around that time, it became an acronym for a combination of physics, numerical mathematics, and, to some extent, computer sciences employed to simulate fluid flows. The beginning of CFD was triggered by the availability of increasingly more powerful mainframes and the advances in CFD.

CFD simulations

The computing times for a flow simulation depend on the choice of numerical algorithms and data structures, linear algebra tools, stopping criteria for iterative solvers, discretization parameters, cost per time step and convergence rates for outer iterations, programming language and many other things. The quality of simulation results depends on the mathematical model and under lying assumptions, approximation type, stability of the numerical scheme, Mesh, timestep, error indicators, stopping criteria etc.

LITERATURE SURVEY

Sebastian Marian ZAHARIA , Rareş Ioan ŞTEFĂNEANU," DESIGN AND MANUFACTURING PROCESS FOR A BALLISTIC MISSILE"

This mission and level of stress the missile will be determined how the flight is designed for a ballistic missile. The Requests from Missile are determined by components organization, flight regime type, engine design, and rocket flight aerodynamics performance. A ballistic missile with a smooth fuselage type, 10 control surfaces, 8 directional surfaces for cornering execution, 2 for manoeuvres of execution to modify the angle of incidence, and 4 stabilizers direction have been designed in this study. The mass of the ballistic missile demonstrated a considerable reduction in weight and a construction with high strength thanks to the technology of gluing and clamping of the shell and the use of titanium components.

Ognjen OGNJANOVIĆ, 2.Stevan MAKSIMOVIĆ, 3.Nenad VIDANOVIĆ, 4.Gordana KASTRATOVIĆ, 5.Katarina MAKSIMOVIĆ," STRUCTURAL ANALYSES OF BALISTIC MISSILE FIN CONFIGURATION DURING SUPERSONIC FLIGHT CONDITIONS"

By this study, the aerodynamic heating and aero-thermomechanical analysis of fin-like structures on the missile during supersonic flight are the main points of focus. In recent years, there has been a lot of discussion about the aerodynamic heating of supersonic and hypersonic aircraft. Because the velocity field and temperature field are connected at high Mach numbers, viscous heating—heat caused by friction between the body and the flow—must be considered. In the ANSYS Workbench environment, the flow field surrounding the missile's fins, in particular the temperature distribution on its surface, as well as

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aerodynamic-thermal and structural evaluations, are numerically modelled. Two Mach numbers (M = 2.3 and M = 3.7 with the same angle of attack of 5°) were investigated.

INTRODUCTION TO CFD

Computational fluid dynamics (CFD) is increasingly applied throughout the development cycle of advanced tactical missiles. This increased reliance on CFD is due, in part, to the increased demands being made on the missiles for higher speed, greater maneuverability, multiple missions, and the maturity of the CFD disci¬pline. Recent CFD developments in multizone struc¬tured, unstructured, and adaptive grids, along with multiprocessor algorithms, have drastically reduced the time required to obtain results.

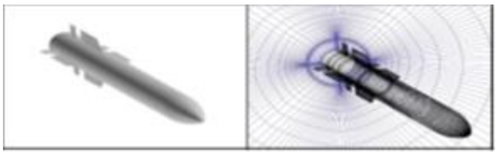


Fig-1 Continuous flow domain of interest.

INTRODUCTION TO CAD

Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software(construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixelated) environments.

The main modules are
Part Design
Assembly
Drawing

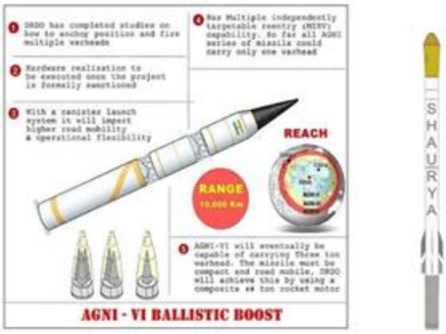


Fig-2 Missile Models

SHARUYA MISSILE:

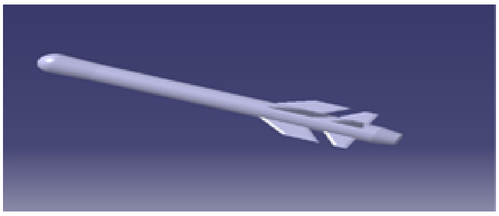


Fig-3 Shaurya Missile Model

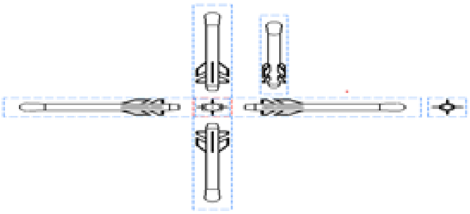


Fig-4 Shaurya Missile Model-Drafting

AGNI MISSILE:

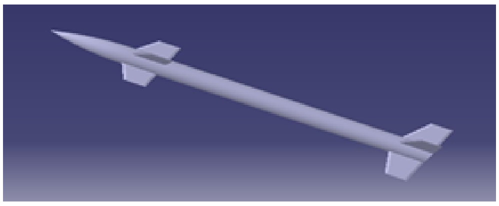


Fig-5 Agni Missile Model

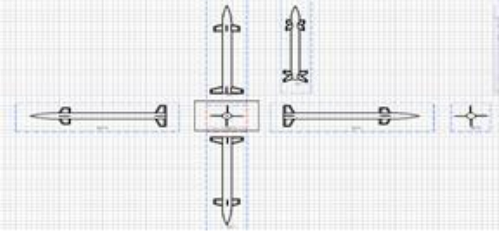


Fig-6 Agni Missile Model- Drafting

INTRODUCTION TO FEA

Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) pre-processing, in which the analyst develops a finite element mesh to divide the subject geometry into subdomains for mathematical analysis, and applies material properties and boundary conditions, (2) solution, during which the program derives the governing matrix equations from the model and solves for the primary quantities, and (3) post-processing, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).

EXPLICIT DYNAMICS

Explicit dynamics is a process used in computational mechanics that allows the simulation of transient, high-speed, and short-duration events such as impacts, explosions, and crash simulations. It is a numerical method that solves the equations of motion using finite element analysis, which divides a complex system into smaller, simpler parts to analyse their behaviour. In explicit dynamics, the time steps are small and the calculations are carried out in a sequential manner. This means that the results are updated at each time step, allowing for the simulation of fast and transient events. The method is particularly useful when dealing with nonlinear material behaviour and large deformations.

STRUCTURAL ANALYSIS OF INTERCONTINENTAL BALLISTIC MISSILE

Explicit Dynamics On Shaurya Missile:

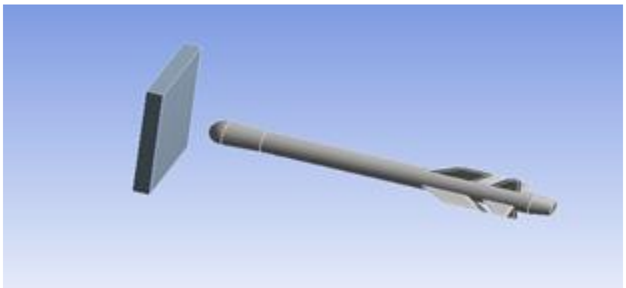


Fig-7 Importing Geometry into Ansys

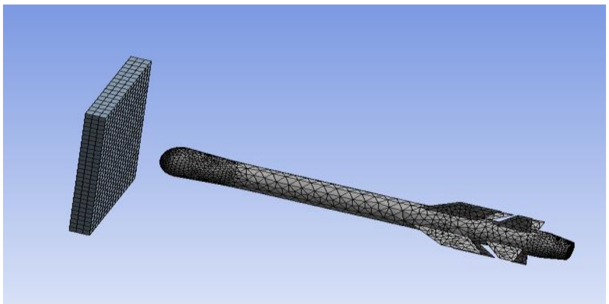


Fig-8 Meshing Body

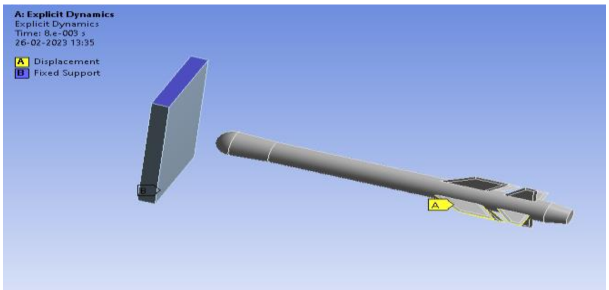


Fig-9 Boundary Conditions

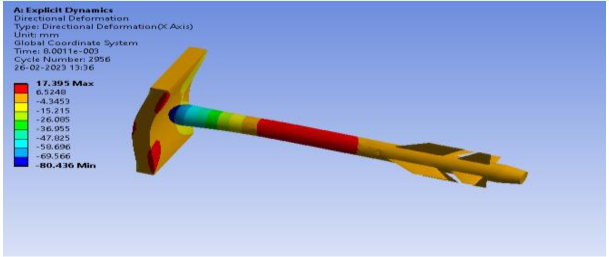


Fig-10 Explicit Dynamics: 17.395MAX

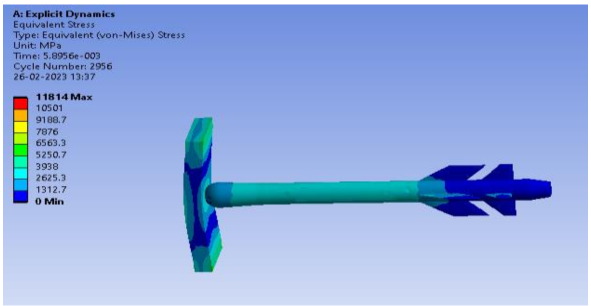


Fig-11 Explicit Dynamics: 11814MAX

Load And Boundary Condition For Shaurya Missile:

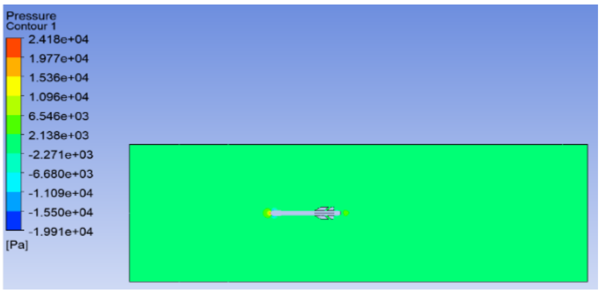


Fig-12 Pressure Contour: 2.418e^4 MPA

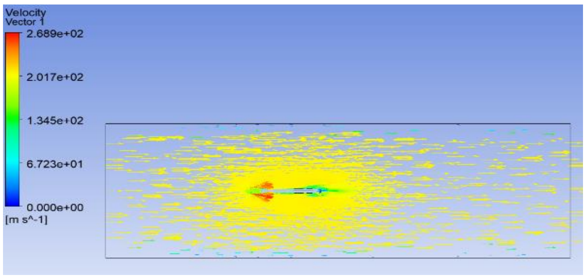


Fig-13 Velocity Vector1: 2.689e^2ms^-1

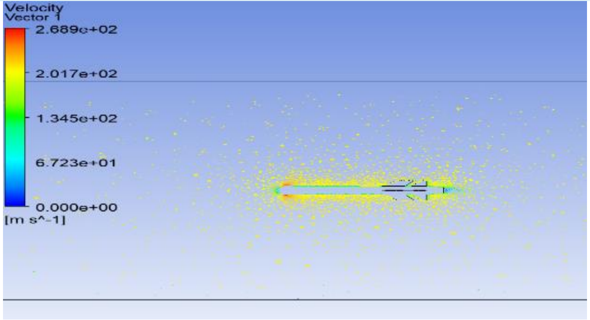


Fig-14 Velocity Vector1: 2.689e^2ms^-1

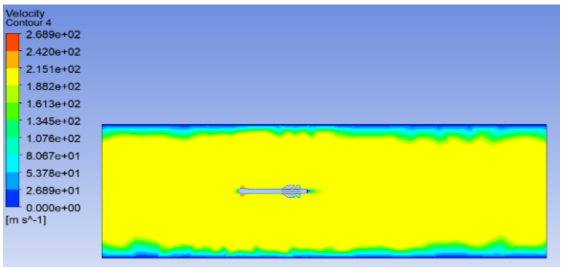


Fig-15 Velocity Contour2: 2.689e^2ms^-1

STRUCTURAL ANALYSIS OF INTERCONTINENTAL BALLISTIC MISSILE

Explicit Dynamics On Agni-Vi Missile

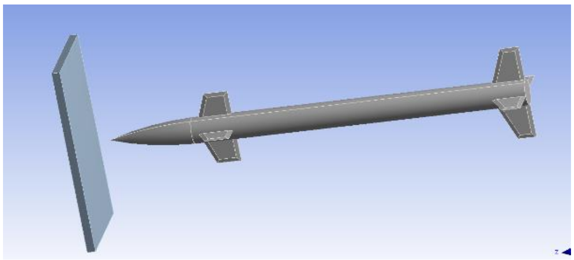


Fig-16 Importing Geometry into Ansys

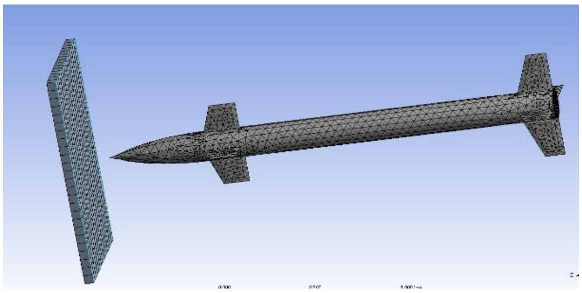


Fig-17 Meshing Body

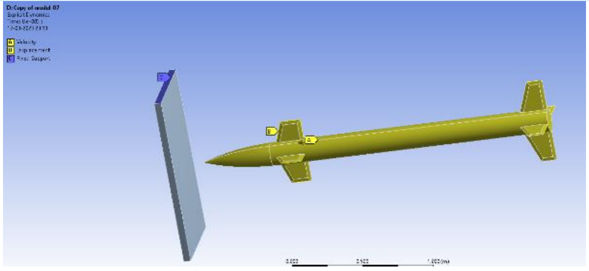


Fig-18 Boundary Conditions

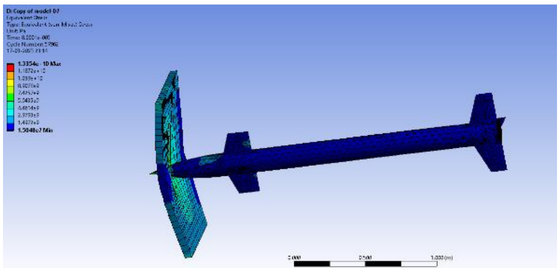


Fig-19 Equivalent Stress: 1.3354e+10Max

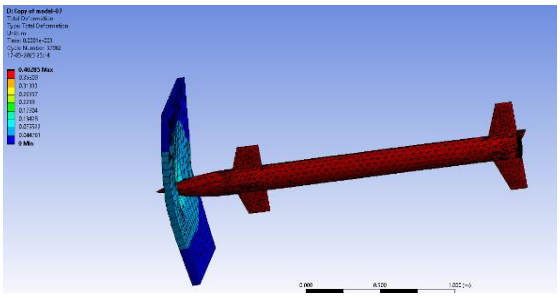


Fig-20 Total Deformation: 0.40285Max

Load And Boundary Condition For Agni Missile :

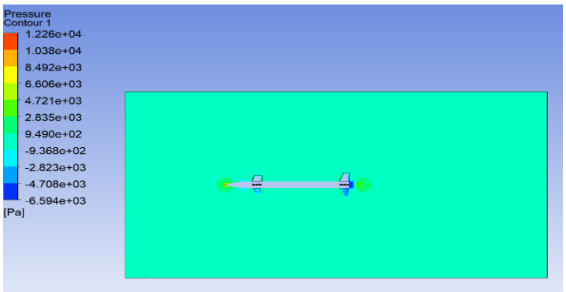


Fig-21 Pressure Contour: 1.226e^4 MPA

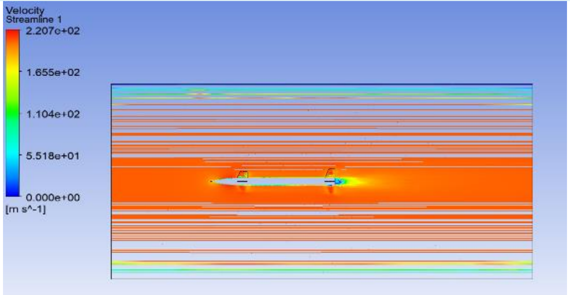


Fig-22 Velocity Streamline: 2.689e^2ms^-1

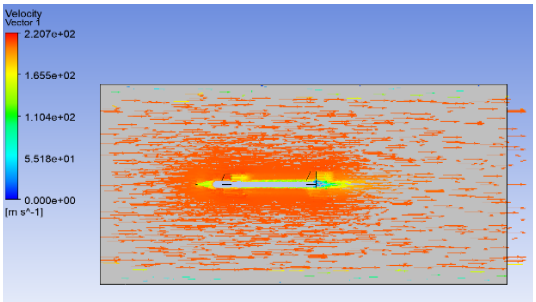


Fig-23 Velocity Vector1: 2.207e^2ms^-1

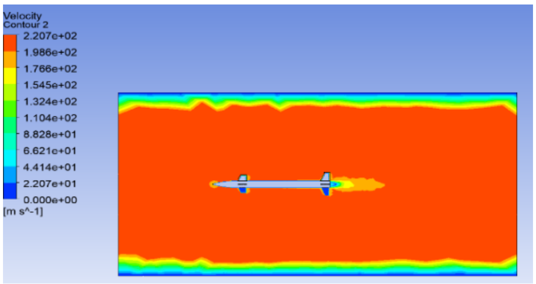


Fig-24 Velocity Contour: 2.207e^2ms^-1

RESULTS & DISCUSSIONS

AGNI-VI MISSILE CFD RESULTS

Agni-Vi Missile Force(N)

ZONE	PRESURE	VISCOUS	TOTAL
MISSILE BODY	-220.12253	-123.52065	-343.64317
NET	-220.12253	-123.52065	-343.64317

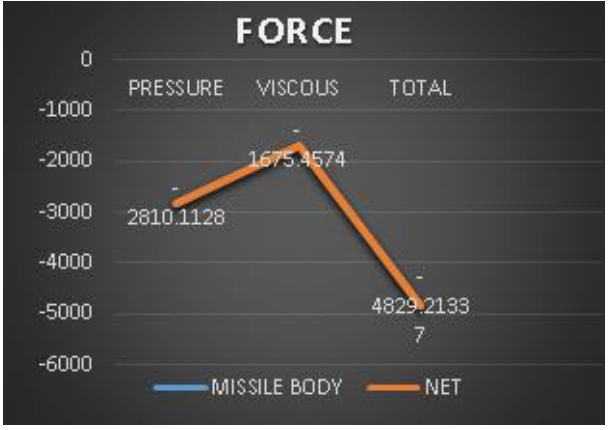
Agni-Vi Missile Coefficients

ZONE	PRESURE	VISCOUS	TOTAL
MISSILE BODY	-359.38372	-201.666636	-561.05008
NET	-359.38372	-201.666636	-561.05008

SHARUYA MISSILE CFD RESULTS

Shaurya Missile Force(N) :

ZONE	PRESURE	VISCOUS	TOTAL
MISSILE BODY	-2810.1128	-1675.4574	-4829.21337
NET	-2810.1128	-1675.4574	-4829.21337

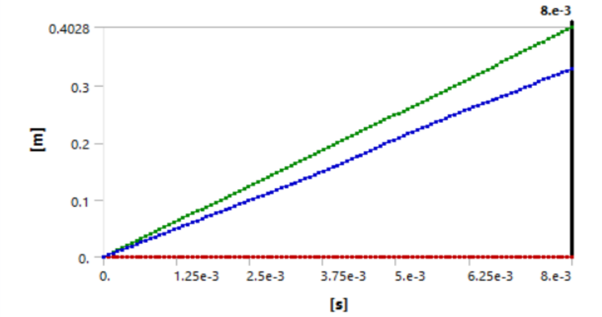


Shaurya Missile Coefficients

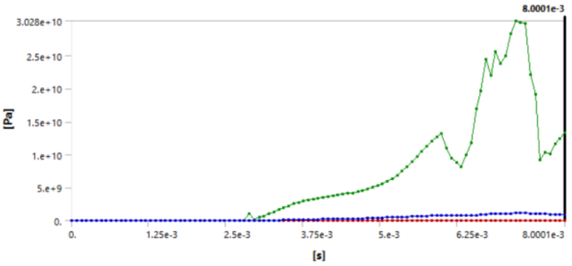
ZONE	PRESURE	VISCOUS	TOTAL
MISSILE BODY	-4585.9393	-2735.4406	-7323.3799
NET	-4585.9393	-2735.4406	-7323.3799

AGNI-VI MISSILE EXPLICIT DYNAMICS RESULTS

Agni-Vi Missile Total Deformation

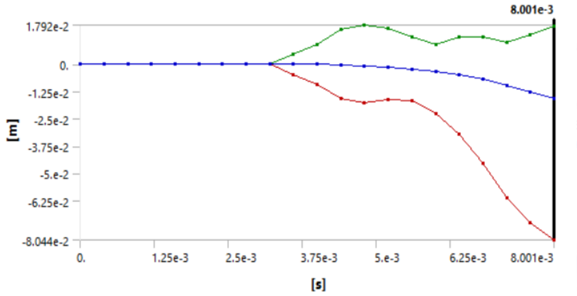


Agni-Vi Missile Equivalent Stress

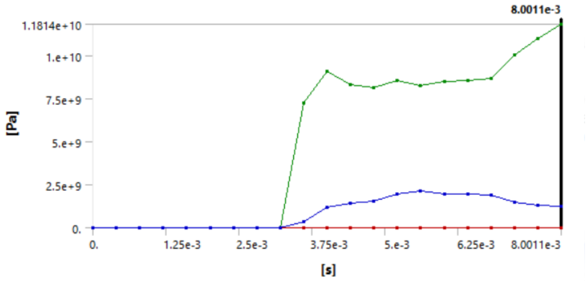


SHARUYA MISSILE EXPLICIT DYNAMICS RESULTS

Shaurya Missile Total Deformation



Shaurya Missile Equivalent Stress



CONCLUSIONS

This article provides excellent examples of how and where CFD has added value to the missile airframe and component development process. The SM Program has significantly benefited from CFD in the design of the IR dome cooling system, SDACS failure analysis, computation of full airframe aerodynamic databases, and tail load computations for flutter analysis. The TACTOM Program has also benefited from CFD through development of a fin-folding loads database and contributory analysis for fin deployment system redesign. These examples demonstrate contributions to the missile development process, from exploratory wind tunnel testing through in-development and in-service flight test phases. Although only a few examples are described here, CFD has impacted, contributed to, and added value to the missile development and risk identification process of several other programs. CFD has become and will continue to be an integral part of the missile design process.

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