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Design and Analysis of Missiles

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ABSTRACT

A missile is a self-propelled precision-guided munition system, as opposed to an unguided self-propelled munition, referred to as a rocket. Missiles have four system components: targeting and/or missile guidance, flight system, engine, and warhead. Missiles come in types adapted for different purposes: surface-to-surface and air-to-surface missiles, surface-to-air missiles, air-to-air missiles, and anti-satellite weapons. All known existing missiles are designed to be propelled during powered flight by chemical reactions inside the engine.

Missiles are sturdy, well-constructed machines. But, because of their size, weight, and bulk, they are not that easy to handle nor are missiles indestructible. Most missile damage is, unfortunately, a result of carelessness and poor handling practices. To reduce the possibility of damage, missiles are shipped, stored and handled with special equipments. Approved containers, canisters, and handling equipments provide maximum missile safety with minimum handling by personnel. The missile container used previously was of lid type (suitcase) containers. This type of container has large contact area at the closing region. So it is very important that the manufacturer has to take extreme care in producing this container without any warpage at the closing region. Else there will be a leakage of gas from the gap developed due to warpage. Therefore the manufacturing becomes more complex and more expensive.

INTRODUCTION

MISSILE:

Basically any object thrown at a target with the aim of hitting it is a missile. Thus, a stone thrown at a bird is a missile. The bird, by using its power of reasoning may evade the missile (the stone) by moving either to the Left, right, top or bottom with respect to the flight path (trajectory) of the missile. Thus, the missile in this case has been ineffective in its objective of hitting the bird (the target) . Now, if the stone too is imparted with some intelligence and quick response to move with respect to the bird, to overcome aiming errors and the bird's evasive actions and hit it accurately, the stone now. Becomes a guided missile.

The incorporation of energy source in a missile to provide the required force for its movement (propulsion), intelligence to go in the correct direction (guidance) and effective maneuvering (control) are mainly the technologies of guided missiles. They help in making a missile specific to a target, that is, they determine the size, range and state of motion of a missile. Missile An object which is forcibly propelled at a target, either by hand or from a mechanical weapon.

The major components of a missile are:

Guided missiles are made up of a series of subassemblies. The various subassemblies form a major section of the overall missile to operate a missile system, such as guidance, control, armament (warhead and fusing), and propulsion. The major sections are carefully joined and connected to each other. They form the complete missile assembly. The arrangement of major sections in the missile assembly varies, depending on the missile type. The guidance section is the brain of the missile. It directs its maneuvers and causes the maneuvers to be executed by the control section. The armament section carries the explosive charge of the missile, and defusing and firing system by which the charge is exploded. The propulsion section provides the force that propels the missile.

Guidance and Control Section The complete missile guidance system includes the electronic sensing systems that initiate the guidance orders and the control system that carries them out. The elements for missile guidance and missile control can be housed in the same section of the missile, or they can be in separate sections. There are a number of basic guidance systems used in guided missiles. Homing-type, air-launched, guided missiles are currently used. They use radar or infrared homing systems. A homing guidance system is one in which the missile seeks out the target, guided by some physical indication from the target itself. Radar reflections or thermal characteristics of targets are possible physical influences on which homing systems are based.

Homing systems are classified as active, semi active, and passive.

- WARHEAD
- FUSING
- GUIDANCE SYSTEM
- PROPULSION SYSTEM
- FINS

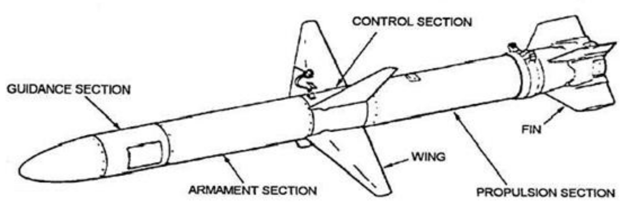

Figure: Nomenulicnature of missile

WARHEAD

A warhead is an explosive device used in military conflicts, used to destroy enemy vehicles or buildings. Typically, a warhead is delivered by a missile, rocket or torpedo. It consists of the explosive material, and a detonator.

FUZING

A proximity fuze is a fuze that detonates an explosive device automatically when the distance to the target becomes smaller than a predetermined value. Proximity fuzes are designed for targets such as planes, missiles, ships at sea and ground forces. They provide a more sophisticated trigger mechanism than the common contact fuze or timed fuze. It is estimated that it would increase the lethality 5 to 10 times.

Sensor types

- Radio
- Optical
- Magnetic
- Acoustic
- Pressure

PROPULSION SYSTEM

Propulsion is the means of providing power to accelerate the missile body and sustain, if necessary, to reach the required target. The basis for the working of missile propulsion systems are the well-known Newton's laws of motion. In order to aid a quick retrospect, these are stated here again.

First Law:

A body continues in its state of rest or in uniform motion in a straight line unless acted upon by an unbalanced force.

Second Law:

The rate of change of momentum is proportional to the impressed force and takes place in the direction of the force.

Third Law:

Action and reaction are equal and opposite. That is, if a body exerts a force on another body, the other body too exerts a force on the first body of the same magnitude but in the opposite direction.

The propulsion of a missile is achieved with the help of a rocket engine. It produces thrust by ejecting very hot gaseous matter, called propellant. The hot gases are produced in the combustion chamber of the rocket engine by chemical reactions. The propellant is exhausted through a nozzle at a high speed. This exhaust causes the rocket to move in the opposite direction (Newton's third law). As per the second law,

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also called the law of momentum, the rate of' change of momentum causes a force to be developed. The change in momentum of the missile body including the rocket motor casing, the nozzle and other systems due to the ejected matter creates a force leading to the propulsive action on the missile body. The missile, propelled into air, would continue to move if there were no other forces acting on it. However, resistance to its forward movement due to air (commonly called the aerodynamic drag) and the force of gravity acting downwards towards the centre of the earth are to be taken into account. By using Newton's first law, also called the law of inertia, compensative forces are imparted to the missile to overcome these negative forces.

Missiles are powered by an engine, generally either a type of rocket engine 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-propellant 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. Missiles often have multiple engine stages, particularly in those launched from the surface. These stages may all be of similar types or may include a mix of engine types – for example, surface-launched cruise missiles often have a rocket booster for launching and a jet engine for sustained flight.

Some missiles may have additional propulsion from another source at launch for example, the V1 was launched by a catapult, and theMGM-51 Shillelagh was fired out of a tank gun (using a smaller charge than would be used for a shell).

Missile propulsion will be mainly of the following two types:

- Air breathing,
- Non-air breathing.

The air breathing rocket engines use the surrounding medium of air for. The support of their oxidiser. Thus they can be used only within the Earth's atmosphere where as in the case of non -air breathing engines the rocket engine itself' carries its fuel and oxidiser on board and hence can be used in space above the Earth's atmosphere also and is thus independent of the air meclihni.Depend,ing on the physical state of matter of the propellant used, the rocket propulsion system is designated as a solid rocket motor, a liquid propulsion system or a hybrid propulsion system.

Classification of propulsion system:

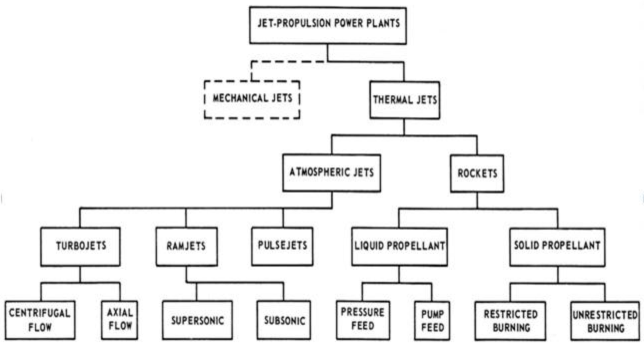

Figure: classifications of engines

Classification of Engines

Historically, engines have evolved from simple conceptions to very complex designs. Yet, several different types of engines continue to be used. For a given application, one particular type may be significantly better than another. For example, one might expect a short-range "puddle jumper" to have different needs than a supersonic fighter. In this section, different types of engines will be defined and described. In the following chapters, the basic principles (including thermodynamics and gas dynamics) of the components and of these engines are covered. Diagrams (such as h-s and p-v) will be included. From these principles, one can predict and compare the different operating characteristics of the various engines and determine what parameters make some engines more appropriate for some applications than others. In the following sections, example details of some current and previously used engines are presented; some outdated engines are discussed for historic purposes. Many of the engines have different sub models or "builds" for different applications, and for these cases typical characteristics are presented. Information was collected from engine data in Aviation Week & Space Technology, Flight International, Mattingly (1996), Treager (1979) engine and airframe manufacturers' materials, brochures, Web pages, and military publications. Although, every effort has been made by to be accurate cross-checking information as much as possible, accuracy cannot be guaranteed because some engines and manufacturers are forever changing.

TESTING OF PROPULSION SYSTEM

Before a rocket engine can be put to use, it has to be tested. This is true whether it is in the case of the quality assurance of a rocket engine, R&D of a new or modified rocket engine or evaluation of the suitability of a new or a modified rocket motor to a specific application. Some of the tests are as follows.

- Manufacturing, inspection and fabrication tests (pressure tests, bursts tests, leak tests, electro-mechanical checks).
- Component tests (functional and operational tests on igniters, valves, injectors, structures, etc.)
- Static rocket systems tests (with complete rocket engine on test stand) : (a) simulated rocket operation (for proper function, calibration, ignition, operation-usually without establishing full combustion or nuclear reactivity); (b) complete engine tests (under rated conditions, off design conditions with intentional variations in environment or calibration).
- Static vehicle tests (when rocket engine is installed in a restrained non-flying vehicle). Flight tests: (a) on a specially instrumented flight test range with special flight test vehicle (b) with production vehicle.

Above all, flight testing of the integrated system is the ultimate in such tests. This is done in conjunction with tests of vehicles and other systems such as guidance, control, ground systems, structures, the details of which are enumerated in the succeeding chapters. These tests are usually conducted at missile or space launch ranges over the oceans. Data from most missile and space flight tests is telemetered to a ground receiving station as the test measurements are made. Some flight tests rely on salvaging some sections or pieces or data capsules. Some form a part of reentry technology and recovery systems.

Uses of Propulsion Systems

As stated earlier, the rocket engines are used in all kinds of missiles, satellite launch vehicles, etc. The technology of warhead guidance accuracy determines the lethal capacity of a missile. These technologies are kept a closely guarded secret by all countries. However, rockets with satellite payloads are used in civil applications. They are particularly used in meteorology, weather forecasting data, survey for minerals, satellite communication, mapping, etc.

Types of missiles

- Conventional guided missiles
- Air-to-air missile
- Air-to-surface missile
- Anti-ballistic missile
- Anti-satellite weapon
- Anti-ship missile
- Anti-submarine missile
- Anti-tank guided missile
- Land-attack missile
- Surface-to-air missile
- Surface-to-surface missile
- Wire-guided missile
- Cruise missiles
- Air-launched cruise missile
- Ground-launched cruise missile
- Submarine-launched cruise missile
- Ballistic missiles
- Tactical ballistic missile
- Short-range ballistic missile
- Theatre ballistic missile
- Medium-range ballistic missile

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- Intermediate-range ballistic missile
- Intercontinental ballistic missile (List of ICBMs/Comparison of ICBMs)
- Submarine-launched ballistic missile
- Air-launched ballistic missile

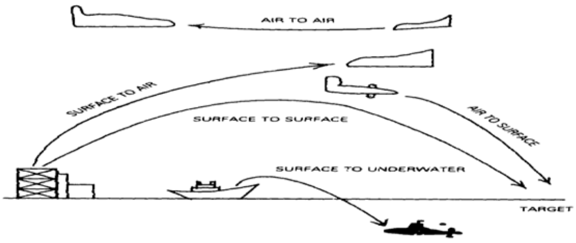

Figure: types of missiles launching

DESIGNING OF MISSILE

Design of nose cone

A warhead is an explosive device used in military conflicts, used to destroy enemy vehicles or buildings. An ogive nose cone has a profile that is segment of circle. The shape parameter value 1 produces a tangent ogive, which has smooth transition to body tube values less than 1 produces secant ogives.

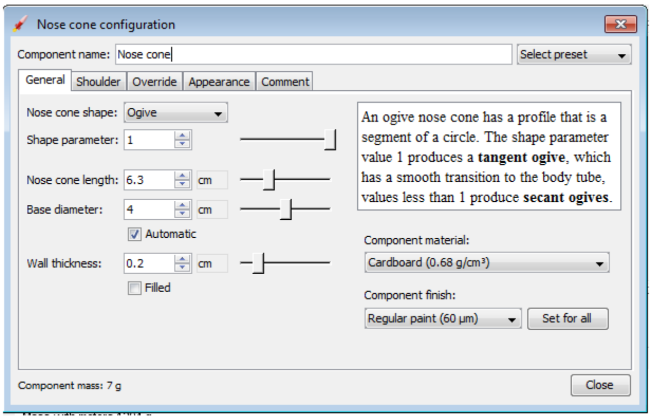

Figure: nose cone table

These are the values of nose cone
Length of nose cone is 63 mm
Diameter of nose cone is 40 mm
Inner diameter of nose cone is 36 mm

Design of cylinder

The dimensions of cylinder
Length of cylinder is 630 mm
Diameter of cylinder is 40 mm
Inner diameter of cylinder is 36 mm

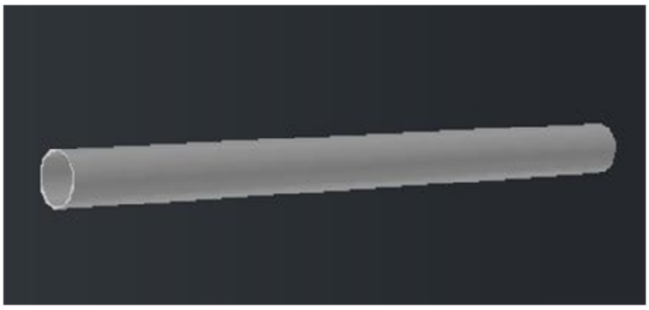

Figure: design of missile cylinder

This is the design of cylinder for missile by using of designing software AutoCAD with the dimensions as given above. This is the figure for cylinder for missile for simulation purpose.

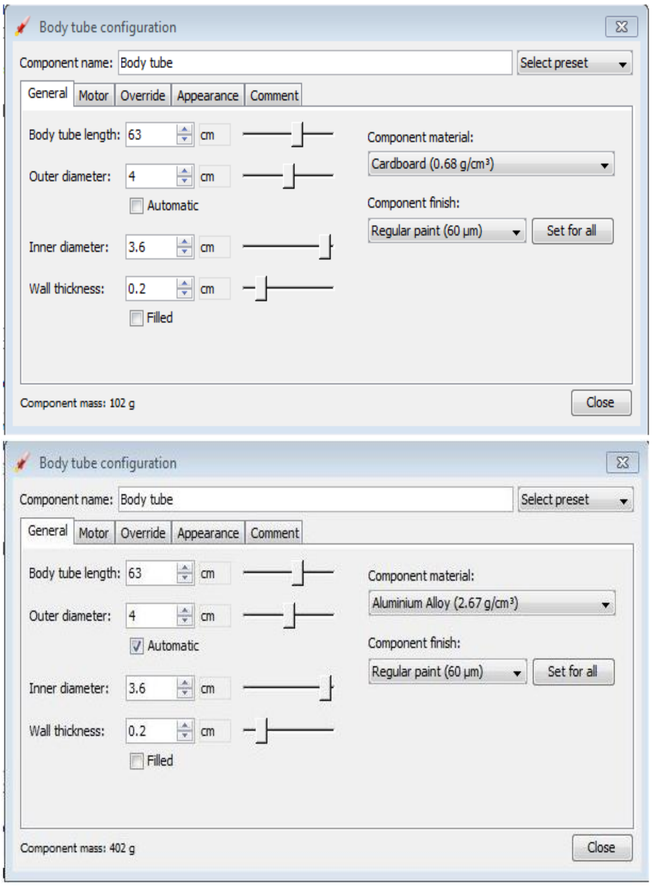

Figure: table of cylinder for missile with different materials Motor for missile:

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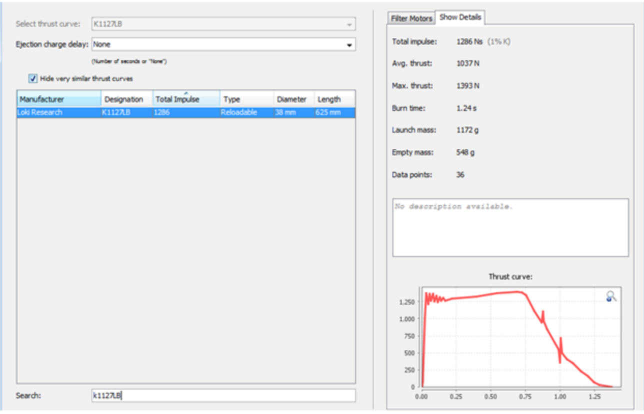

Figure: figure of motor with details

This is type of motor which can reloadable and the maximum impulse of motor is 1286 Ns. And the details of motor as given below
Manufacturer: Loki research
Total impulse: 1286 Ns
Average thrust: 1037 N
Maximum thrust: 1393 N
Time taken to burn propellant: 1.24s
Weight of motor: 1.172 kg

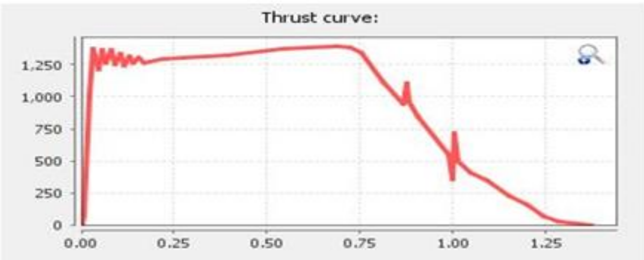

Figure: Thrust curve

Design of missile

This is the final missile that we created in design software and we have done simulation. And the dimensions are as follows
Total length of the missile is 744 mm
Diameter of missile is 40 mm
Total weight of missile is 1.300 kg
Position of centre of gravity is 381 mm from nose cone
Position of centre of pressure is 495 mm from nose cone
Maximum velocity of missile is 1094 m/s
Mach number of missile is 3.24
Maximum acceleration is 1817 m/s^2

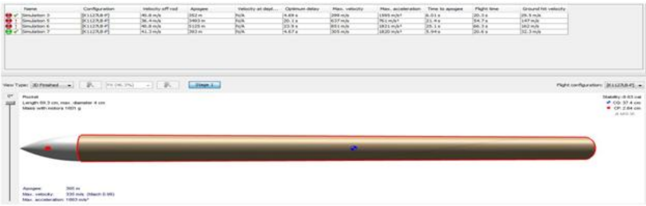

Figure: missile without fins

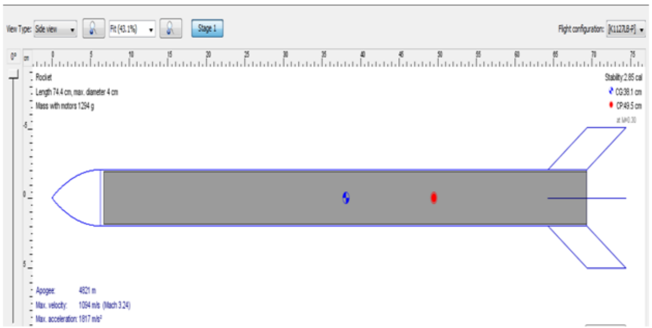

Figure: Two dimensional figure of missile

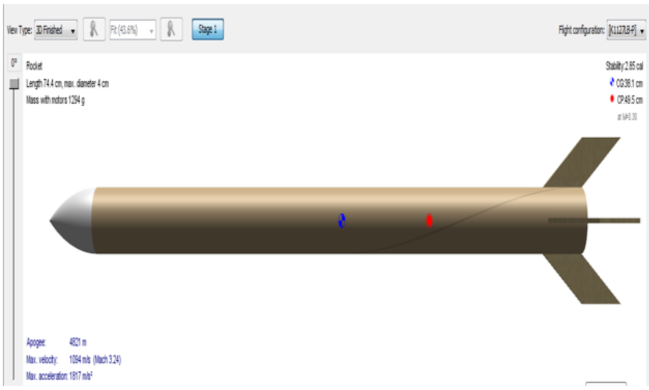

Figure: Three dimensional figure of missile

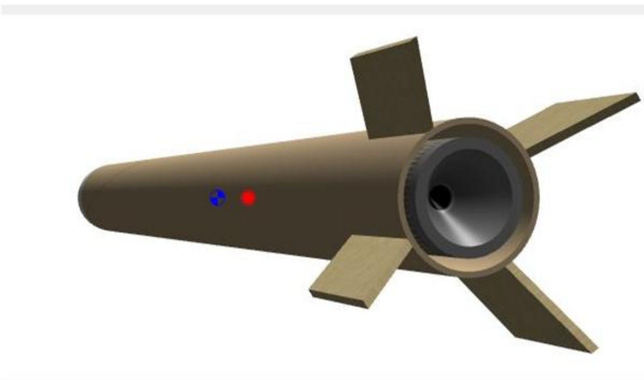

Figure: Different view of missile with 4 fins

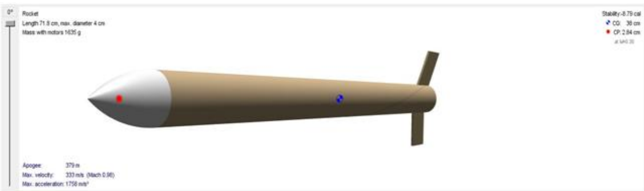

Figure: 2- fin missiles with composites

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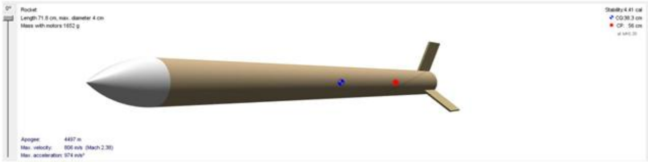


Figure: 3- fin missiles with composites

Figure: Elliptical fin missiles with composites

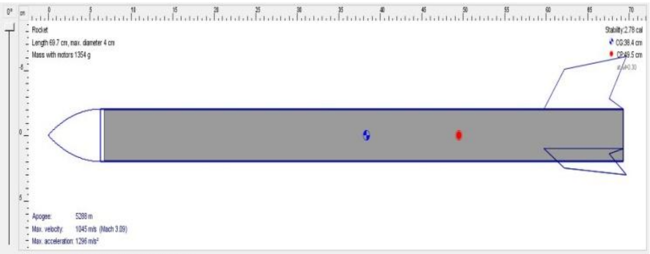


Figure: different structure fins missile with composites

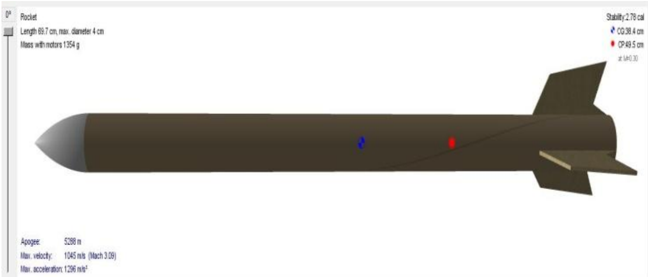
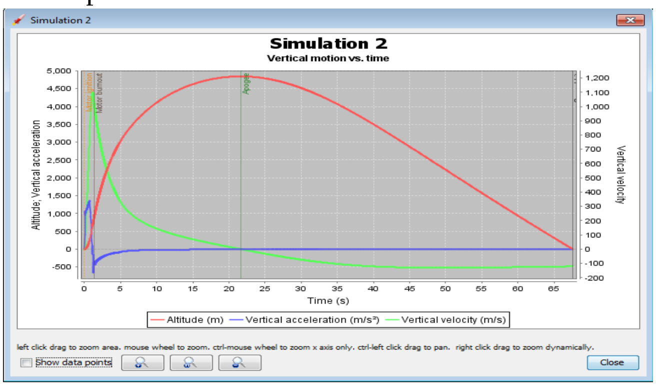


Figure: Different structure fins missile with composites

SIMULATION OF MISSILE

The process of simulating rocket flight can be broken down into the following. Initialize the rocket in a known position and orientation at time.



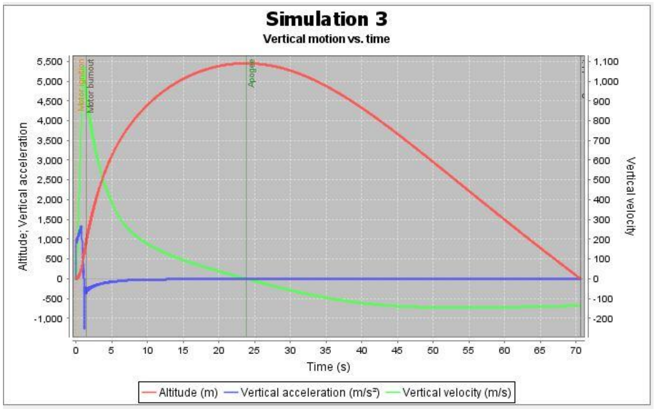


Figure: simulation of missiles

Simulation 1

This is the graph of velocity plot, altitude plot and acceleration plot results of designed missile. It is representing the motion of missile with respect to time the trajectory of missile.

Maximum velocity of missile is 1094 m/s,
Mach number of missile is 3.24,
Maximum acceleration is 1817 m/s^2,
Range is 4821 m,
Number of fins: 4

Simulation 2

This is the graph of velocity plot, altitude plot and acceleration plot results of designed missile. It is representing the motion of missile with respect to time the trajectory of missile.

Maximum velocity of missile is 1073 m/s,
Mach number of missile is 3.18,
Maximum acceleration is 3293 m/s^2,
Range is 5288 m,
Number of fins: 3

Simulation of missiles with different configuration

Name	Configuration	Velocity off rod	Apogee	Velocity at depl...	Optimum delay	Max. velocity	Max. acceleration	Time to apogee	Flight time	Ground hit velocity
Simulation 3	[K1127LB-P]	40.8 m/s	352 m	N/A	4.69 s	299 m/s	1595 m/s²	6.01 s	20.3 s	29.5 m/s
Simulation 5	[K1127LB-P]	36.4 m/s	3493 m	N/A	20.1 s	637 m/s	761 m/s²	21.4 s	54.7 s	147 m/s
Simulation 6	[K1127LB-P]	40.8 m/s	5125 m	N/A	23.9 s	851 m/s	1821 m/s²	25.1 s	66.3 s	162 m/s
Simulation 7	[K1127LB-P]	41.3 m/s	393 m	N/A	4.67 s	305 m/s	1820 m/s²	5.94 s	20.6 s	32.3 m/s
Simulation 8	[K1127LB-P]	40.9 m/s	4984 m	N/A	23.3 s	837 m/s	1012 m/s²	24.6 s	238 s	26 m/s

Name	Configuration	Velocity off rod	Apogee	Velocity at depl...	Optimum delay	Max. velocity	Max. acceleration	Time to apogee	Flight time	Ground hit velocity
Simulation 1	[K1127LB-P]									
Simulation 2	[K1127LB-P]	45.3 m/s	5285 m	N/A	22.1 s	1046 m/s	1293 m/s²	23.4 s	287 s	31.6 m/s
Simulation 3	[K1127LB-P]	45.4 m/s	5450 m	N/A	22.5 s	1068 m/s	3257 m/s²	23.8 s	70.6 s	136 m/s

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CONCLUSION

The conclusion of this project is that the missile with different fins and different material used in manufacturing leads to variable results in velocity, acceleration and range. As given in above simulations we have observed that when with different fins like 2 fins, 3 fins and different shaped fins leads to high Mach number of missile.

And the main propulsion system should be efficient such as solid propellant because we can store solid propellant but we can't store the liquid propellant it should be in short time period and its cost effected. Solid propellant is quite simple to use than liquid propellant. The compositions of solid propellant will be good in impulse. Thus the solid propellant is the good fuel to use in missiles.

In this project I just want tell about the structure of the missile is important and the affect of the aerodynamic forces, the stability all will be includes. The mainly the structure of fins, they can produce less drag forces and increase the speed of the missile. In this project I have used different type of structure with these fins the missile gained the speed and the range. Mainly the missiles are used for striking of aim, thus if the missile has good speed it can strike the aim as early as it reaches.

When we observe in the simulation graph and table, the differences of simulations and the positions of missile with respect to time. It is used only surface to surface only. This type of missile within the range of 5 km. was can carry of 1 kg of payload in the warhead. There will be no such a guidance system used in it is based on the angle of attack and degree of projectile of missile.

The rocket-propelled grenade these typically also use a small recoilless charge or compressed gas system to get the projectile out of the barrel and to a distance where the operator will not be hurt by the rocket's back blast when the rocket ignites at a safe distance, it further accelerates the projectile or at least keeps it from decelerating in its trajectory. Shoulder-launched weapons may be guided or unguided. Missiles can either have a disposable launcher. These missiles are suitable for shoulder launch and safe but precautions should be take care.

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