



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 8, August 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.569**

9940 572 462

6381 907 438

[ijrset@gmail.com](mailto:ijrset@gmail.com)

[www.ijrset.com](http://www.ijrset.com)

# Design, Analysis & Testing of High Speed Reciprocating Sub-Systems

**Rahul S. Badgajar, Associate Prof. Dr. A.S. Relkar, Snehal Bharat Patil**

PG Student, Department of Mechanical Engineering, Sandip University, Nashik, India

Department of Mechanical Engineering, Sandip University, Nashik, India

UG Student, Department of Mechanical Engineering, Govt. College of Engineering, Jalgaon, India

**ABSTRACT:** We took up the project 'Design, Analysis and Testing of High Speed Reciprocating Sub- systems', assigned to us by Larsen & Toubro Ltd., in order to get an insight into the world of guns. With India taking up several projects in the defence sector recently, it seemed the perfect opportunity to understand the complexities involved in the making of a particular weapon, with all the basics related to the field of mechanical engineering.

A thorough research was done on all the components of guns like AK-47 and M-16, their functions, various mechanisms involved, with the help of reference books, information available through many useful sites, research papers and detailed videos.

Our primary aim was to design the major parts and assemblies, fulfilling certain criteria. The main processes were studied and depicted through our designed models. Strength analysis of two components, playing a crucial role in the firing process, were done. Another important aspect of our project was with reference to the internal ballistics, wherein all the laws affecting the process were studied in depth. An algorithm was developed considering certain approximations and the plots obtained were similar to the standard ones already available.

We were supposed to work on the experimentation of the test setup to determine the strength and hardenability of particular materials. But due to certain issues, it was not imported within the stipulated time. But it is expected to start in early May. In the future, design and fabrication of multi-calibre guns is also expected.

## OBJECTIVES:

- 1) To design all the major components with reference to AK- 47.
- 2) To obtain plots for internal ballistic processes.
- 3) To do the static analysis of the impacting parts.

## I. HISTORY

### I.I Brief information on the AK-47:

The AK-47 is a 7.62x39 mm assault Rifle first developed in the Soviet Union by Mikhail Kalashnikov. First incarnation Of Kalashnikov assault rifles family was the AK-47, named to coincide with the year of its entry into active service (1947) It is officially known as Avtomat Kalashnikova (or sim

ply 'AK'). It is also known as a Kalashnikov or Russian jargon Kalash.

AK-47 Assault Rife, the most recognisable gun in the world and probably most infamous gun there has been. It is estimated that there are between 50 and 70 million of them spread across the world. All 7.62-mm Kalashnikov assault

rifles are very dependable weapons. They produce a high volume of fire and are simple to maintain. Can fire 600 rounds per minute.

#### I.II Reliability and wide use:

The original AK-47 was one of the first true assault rifles. Even after six decades because of its durability, low production cost, and ease of use the model and its variants remain the most widely used and popular assault rifles in the world. It has been manufactured in many countries and has seen service with regular armed forces as well as irregular, revolutionary and terrorist organizations, worldwide. The AK-47 was the basis for developing many other types of individual and crew-served firearms. More AK-type rifles have been produced than all other assault rifles combined.

#### I.III Operation:

The AK-47 is a semi-automatic military assault rifle. It can be fired in single shot mode or can be set for automatic fire by the simple operation of a lever located near the trigger mechanism. In automatic mode, the AK-47 can be fired at a rate of 600 rounds per minute as long as the trigger remains depressed, although its magazine can only store 30 rounds, which will empty in a little over 3 seconds. To fire, the operator inserts a loaded magazine, moves the selector lever off of safety, pulls back and releases the charging handle, aims, and then pulls the trigger. In this setting, the firearm fires only once (semi-automatic), requiring the trigger to be released and depressed again for the next shot. With the selector in the middle position (full-automatic), the rifle continues to fire, automatically cycling fresh rounds into the chamber, until the magazine is exhausted or pressure is released from the trigger. As each bullet travels through the barrel, a portion of the gases expanding behind it is diverted into the gas tube above the barrel, where it impacts the gas piston. The piston, in turn, is driven backward, pushing the bolt carrier, which causes the bolt to move backwards, ejecting the spent round, and chambering a new round when the recoil spring pushes it back.

#### I.IV Ballistics:

The standard AK-47 or AKM fires the 7.62x39mm cartridge with a muzzle velocity of (2,300 ft/s). Muzzle energy is 2,010 joules (1,480 ft·lbf). Projectile weight is normally 7.8 grams (120 gr). The AK-47 and AKM, with the 7.62x39mm cartridge, have a maximum effective range of around (1,300 ft). Ballistics

## II. MAJOR COMPONENTS OF A RIFLE:

### II.I) GUN BARREL:

A gun barrel is the tube, usually metal, through which a controlled explosion or rapid expansion of gases are released in order to propel a projectile out of the end at a high velocity. The barrel provides a guide and support for the projectile as it is accelerated by the impulse of the propellant gases during the interior ballistic cycle.



Fig II.I GUN BARREL

## II.II)MAGAZINE:

A magazine is an ammunition storage and feeding device within or attached to a repeating firearm. Magazines may be integral to the firearm (fixed) or removable (detachable). The magazine functions by moving the cartridges stored in the magazine into a position where they may be loaded into the chamber by the action of the firearm.

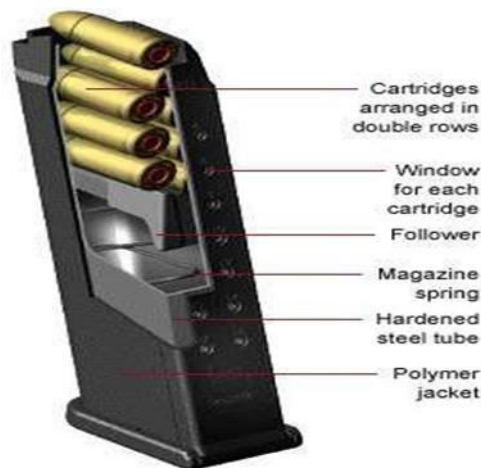


Fig II.II MAGAZINE

## II.III)RECEIVER:

In firearms terminology, the receiver is the part of a firearm that houses the operating parts. The receiver usually contains the bolt carrier group, trigger group, and magazine port. In most handguns, the receiver or frame, holds the magazine well or rotary magazine as well as the trigger mechanism. It is sometimes called the body of the firearm, while in the context of handguns (revolvers and pistols), it is often called the frame. It is often made of forged, machined or stamped steel or aluminum; in addition to these traditional materials, modern science and engineering have introduced polymers and sintered metal powders to receiver construction.



Fig II.III RECEIVER

## II.IV)BOLT:

Bolt action is a type of firearm action in which the weapon's bolt is operated manually by the opening and closing of the breech (barrel) with a small handle, most commonly placed on the right-hand side of the weapon (for right-handed users). As the handle is operated, the bolt is unlocked, the breech is opened, the spent shell casing is withdrawn and ejected, the firing pin is cocked (this occurs either on the opening or closing of the bolt, depending on design), and finally a new round/shell (if available) is placed into the breech and the bolt closed. Bolt action firearms are most often rifles, but there are some bolt-action shotguns and a few handguns as well.



FigII.IVBOLT

#### II.IV)HAMMER:

The hammer is the part that hits the firing pin when you pull the trigger. They are spring tensioned masses of metal that pivot on a pin when released and strike a firing pin to discharge a cartridge.

#### II.VI)TRIGGER:

A trigger is a mechanism that actuates the firing sequence of firearms, or a power tool. Triggers almost universally consist of levers or buttons actuated by the index finger. Rare variations use the thumb or weak fingers to actuate the trigger. Examples are the M2 Browning machine gun and the Springfield Armory M6 Scout.

#### II.VII)CARTRIDGE:

A cartridge, also called a round, packages the bullet, gunpowder and primer into a single metallic case precisely made to fit the firing chamber of a firearm. The primer is a small charge of impact-sensitive chemical that may be located at the center of the case head (center-fire ammunition) or at its rim (rim-fire ammunition). Electrically fired cartridges have also been made. Case-less ammunition has been made as well. A cartridge without a bullet is called a blank; one that is completely inert is called a dummy.

#### II.VIII)BULLET:

Bullets are a bit like fireworks and they are arranged in three sections: the primer, the propellant, and the bullet proper. At the back, the primer (or percussion cap) is like the fuse of a firework: a small fire that starts a bigger one. The next section of the bullet, effectively its "main engine," is a chemical explosive called a propellant. Its job is to power the bullet through the air from the gun to the target. The front part of the bullet is a tapering metal cylinder that hits the target at high speed.

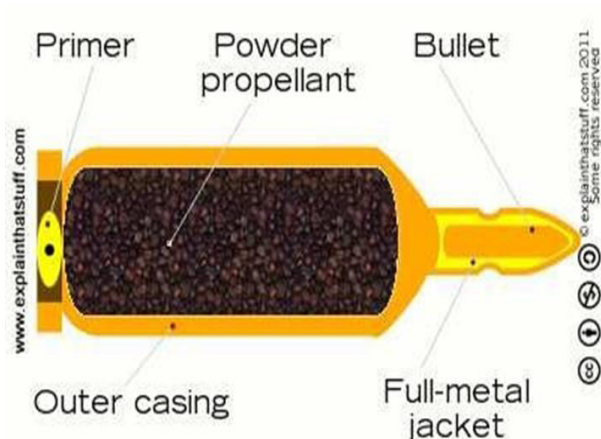


Fig II.VIII BULLET



**III. PURPOSE**

To suggest improvements in design features like robustness, modularity, interlocking, ease of operation, material corrosion, weight reduction, effort in handling, ergonomics etc. for extreme environmental conditions.

**IV. INTERNAL BALLISTICS:**

IV.I)Physical Foundation of Interior Ballistics:

Interior ballistics is the applied physics required to impart motion to a projectile inside a gun tube. Despite its long history and wide application, active research continues with efforts to build more realistic models of the complicated chemical, thermodynamic, and dynamic processes involved. The classic interior ballistics problem is: given the characteristics of the gun, charge, and projectile determine the muzzle velocity of the projectile and the peak pressure in the gun. There is a large knowledge base of both theoretically sound and experimentally proven concepts that make the solution of the interior ballistics problem possible. The burning of chemical compounds, called propellants, is an important part of interior ballistics. The combustion processes depend on many factors including the propellant material and its geometry, the rate of burn, propellant packing and packaging, and environmental factors. The resulting gases produce the pressure field that imparts acceleration to the projectile. The design of the propellant grain shape to achieve the desired pressure-time history, given the constraints imposed by the gun system and projectile, is part of the design effort. The purpose is usually to maximize the projectile muzzle velocity.

IV.II)Gun Nomenclature:

The cannon is a tube that is closed at one end for firing. The barrel provides a guide and support for the projectile as it is accelerated by the impulse of the propellant gases during the interior ballistic cycle. The breech is opened to allow the projectile to be loaded and

is closed for firing. In front of the breech is the reaction chamber that usually has a greater diameter than the remainder of the barrel. It holds the propellant and it is here that ignition and the initial pressure build-up occurs. At the front end of the reaction chamber is an area whose walls taper down to the barrel diameter. This area is called the shoulder. Forward of the shoulder the gun barrel has a uniform diameter, called the gun bore, which continues to the muzzle.

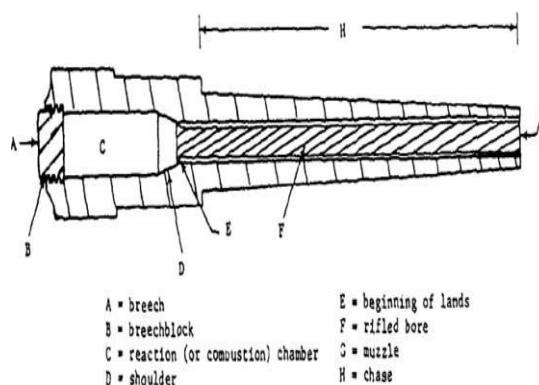


Fig IV.IITypical gun nomenclature

IV.III)Interior Ballistic Cycle:

The interior ballistic cycle starts at propellant ignition. After the propellant is ignited, pressure and heat rapidly increase inside the chamber from the generation of combustion gases. Projectile motion begins after this pressure has overcome the resistance caused by the initiation of engraving the projectile's rotating band by the bore. Pressure increases until the rate of volume increase overcomes the rate of propellant gas generation. Acceleration continues as long as there is a pressure differential across the projectile. The interior ballistic cycle ends when the projectile leaves the gun tube.

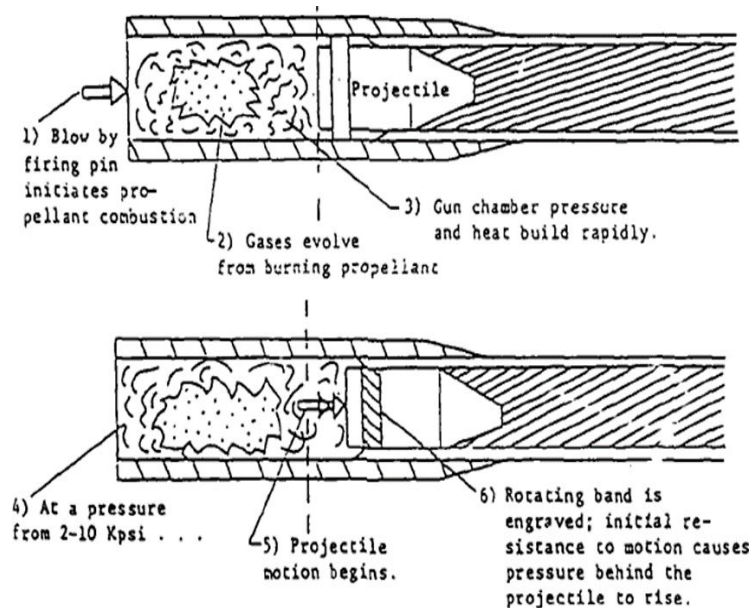


Fig IV.III Interior Ballistics Cycle

#### IV.IV) Projectile Equations of Motion:

A gun is a simple heat engine in which chemical energy of the propellant is transformed into kinetic energy of the projectile and heat. Newton's Second Law is

$$a = F/m$$

where at time  $t$  projectile acceleration equals the net force generated by propellant combustion divided by effective mass. The projectile maintains a constant in bore.

mass. The integral of acceleration with respect to time yields velocity while a subsequent integration gives the distance the projectile has travelled (travel).

#### IV.V) Modelling Approximations:

Modelling the interior ballistic cycle uses the following conditions:

- 1) The propellant gas mixture is described by the Noble-Abel equation of state. This means that the gases are well mixed and no solid or liquid phases exist.
- 2) The propellant gas flow is taken to be one-dimensional, inviscid, and compressible.
- 3) The steady state burning rate law can be used to describe the recession of the rate of the propellant grains.
- 4) The base of the projectile is flat and perpendicular to the direction of travel.
- 5) Propellant grains are all the same size and configuration for a given propellant load. For perforated propellants, all holes are placed in the grain symmetrically.
- 6) All propellant is ignited simultaneously and uniformly. The igniter is consumed by  $t=0$ .
- 7) All exposed burning surfaces recede at the same rate and perpendicular to the surface. That is the grains shrink uniformly without deformation.

8) Decomposition of a unit mass of propellant will always liberate the same amount of energy, which heats product gases to the same temperatures.

## V. FUTURE PROSPECTS

The test setup's design is as shown below:

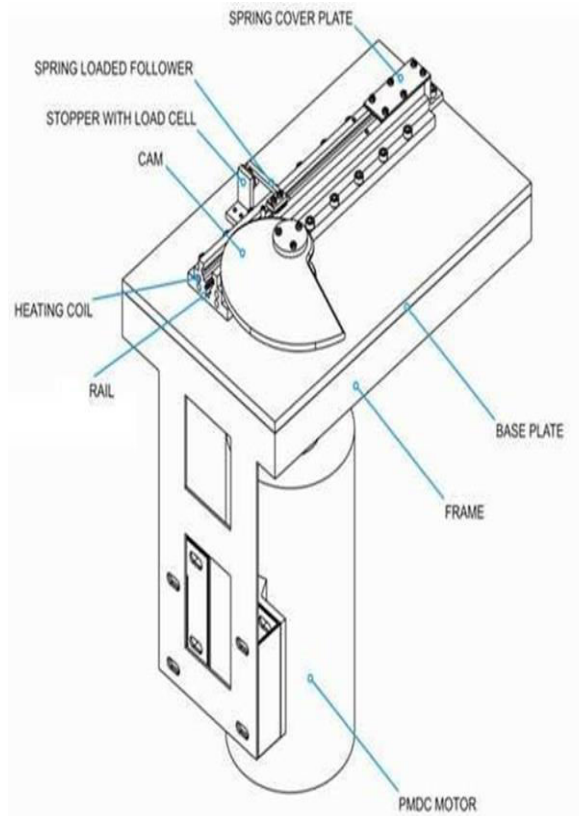


Fig. Test setup design

The main aim is to check the cocking mechanism with different materials chosen on the basis of their grade of hardenability and subjected to extreme conditions of temperature. However their names cannot be disclosed because of security reasons. The setup includes vortex tubes to provide the desired temperatures, linear variable differential transformer to measure the strain induced in the chosen material. There are also proximity sensors to check if the entire stroke has been completed by the movement of the cam.

## VI. CONCLUSION

We are fully studied for measuring high speed of AK-47 gun with the help of ANSYS software. To design the major parts of AK-47 gun such as software using ANSYS & CATIA. AK-47 barrel & bolt were milled out of steel billet. AK-47 was manufactured in basic design with wooden stock.

## REFERENCES

- 1) Robert A. Rinker, 'Understanding Firearm Ballistics', pp. 10-53
- 2) Joe Robert Gonzalez, (June 1990), 'Internal Ballistics Optimization', pp. 29-46
- 3) D. Carlucci & S. Jacobson, (2008), 'Ballistics – Theory and design of guns and ammunition', pp. 23-32.
- 4) Joseph E Shigley and Charles R Mischke, 'Mechanical Engineering Design', pp. 661- 667.
- 5) Walter H. Squire, (1972), 'An Analysis Of 5.56mm Aluminum Cartridge Case Burn- Through Phenomenon', Philadelphia, Pennsylvania, pp. 385-





392.

6)Ludwig Stiefel , (June 1980), ‘Thermochemical And Burning Rate Properties Of Deterred Us Small Arms Propellants’, Table 1, 3, 12.

7)Michal Pedzisz& Marek Wojtyra, ‘ Dynamical Analysis of Semi-automatic Sniper Rifle’, Institute of Aeronautics and Applied Mechanics, Warsaw University of Technology, Poland, pp.1-5.

8)W. F. Morrison, G. P. Wren, W. F. Oberle, S. L. Richardson,( Feb 1993)



**Impact Factor:  
7.569**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details