Review on Development of Mathematical Model for Vacuum Damped Recoil System

Yogesh Ashok Varade[1] Dr. A. V. Vanalkar[2] Dr. S. R. Ikhar[3]
[1]M. Tech. Student [2]Professor [3]Associate Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]K. D. K. College of Engineering, Nagpur, Maharashtra India

Abstract— Recoil system is a core part of any artillery weapon and time required between two consecutive firing of weapon is largely depends on it. Recoil system is used to absorb the recoil force during firing and to return the connecting parts in original firing position. Generally the recoil systems are used in artillery weapon like canon comprised of a hydraulic type system which consist of spring - mass - dashpot. Since these systems are all quite complexes and contain several moving parts, their reliability is limited. Hence here attempt is made to develop vacuum damped recoil system, to predict response of vacuum damped recoil system mathematical model is formulated. Mathematical model usually describe a system by a set of variables and set of equation that establish relationship between the variables.

Key words: Recoil System, Total Cycle Time, Mathematical Model

I. INTRODUCTION

Recoil is the backward momentum of an artillery weapon when shell is fired. When an artillery weapon is fired the burning propellant charge generates a blast of pressurized gasses that impose enormous load on the projectile as well as on the structure. Old fashioned artillery weapons without a recoil system roll several meters backward when fired. When an artillery weapon fire imparts strong impulse load on structure. It is necessary to put control on these load appropriately. To mitigate such a strong impulse and to maintain the displacement of recoil mass within specified limit traditionally recoil absorber that control the recoil force by absorbing the propellant gas impulse are used. Generally the recoil system utilize component such as stiff spring, a damper etc. after firing artillery weapon recoil and moves outward. Due to certain damping system it move inward and retain its initial position. The time required for outward and inward motion is called as total cycle time. For any artillery weapon it is important that time between consecutive firing should be minimum.

II. PURPOSE OF A RECOIL SYSTEM

The primary purpose of a recoil system is to eliminate weight and at the same time retain stability. It also minimizes the requirement for ruggedness. A recoil system is designed to absorb the energy of recoil gradually, thus avoiding violent shock to, or movement of the carriage and to return the recoiling parts to the in-battery position with a minimum of shock. It must also hold the recoiling parts in battery until the weapon is fired again. The four functions of the recoil system are to –

- Stop the recoiling parts.
- Return the recoiling parts to the firing position that is to the in-battery position.
- Perform the above action without excessive shock to carriage.
- Hold the tube and recoiling parts in the firing position throughout all angles of elevation.

III. OBJECTIVE

The objectives of proposed work are as follows.

- To study the existing recoil system of an artillery weapon.
- To identify the problems in recoil system of artillery weapon.
- To study the behavior of vacuum damped recoil system.
- To formulate the mathematical model for vacuum damped recoil system.

IV. RESEARCH METHODOLOGY

- Data accumulation
- Literature review
- Problem identification
- Experimentation of vacuum damped recoil system
- Formulation of Mathematical model
- Validation of Mathematical model
- Result discussion
- Conclusion

V. LITERATURE REVIEW

"Design and Performance Analysis of Smart Fluid Damper for Gun Recoil System" this paper describes to deal variations in loads the smart fluid damper is designed. For designing the damper thorough study of smart fluid and gun recoil dynamics is carried out, as the MR fluids have higher yield strength than that of ER they are selected for this applications. During designing of damper the effect of various parameters on damping force and dynamic range are studied. The trade-off between number of coils and dynamic range has been found out. Once the damper is designed the mathematical modeling of gun recoil system is formulated.

"On Dynamics of a Cannon Barrel-Recoil Mechanism with Nonlinear Hydraulic Damper and Air-Springs" this paper describe the dynamics of the barrel assembly-recoil mechanism of military cannons when using air springs and hydraulic dampers of nonlinear characteristics in their recoil mechanisms. The nonlinear characteristics of the damper and spring and the recoil mechanism orientation introduce extra nonlinearity to the dynamic model of the system. An extremely nonlinear model of the barrel assembly is derived and solved using Runge-Kutta 4 method to provide the dynamic response of the barrel assembly upon firing. The performance of the recoil mechanism is evaluated through the minimum and maximum displacements of the barrel

assembly, the settling time of its response upon firing and the steady-state error of its time response.

"Experimental mechanical device for recoil simulation" presented experimental mechanical setup was designed to provide an experimental data for the purpose of the research and development of the device for the gun's recoil simulation. The main idea for the design and development is to simulate gun's recoil and behavior as realistically as possible and therein make the training shooting more faithful. Mechanical setup was designed for the purpose of acquisition of the force diagrams provided by the present pneumatic and electromagnetic recoil simulation devices, which use the mechanical impact for the recoil force generation. Obtained force diagrams provide the image of the behavior and dimension of the generated force from the mechanical impact.

"Comparison of the recoil of conventional and electromagnetic cannon" this paper describe the recoil from an electromagnetic (EM) rail gun is discussed and compared with that from conventional, propellant gas driven cannon. It is shown that, under similar launch conditions, the recoil of the EM gun is less than that of the powder gun; however, use of a muzzle brake on a powder gun can alter this relative behavior.

"A Development of Recoil & Counter Recoil Motion Measurement System Using LVDT" this paper describes a recoil and counter recoil motion measurement system using linear variable differential transformers (LVDT). The output of the LVDT is obtained from the differential voltage of the secondary transformers. Since a transducer core is attached to the motion body, the output is directly proportional to the movement length of the core. Displacement, velocity and acceleration are measured from the LVDT. With a comparison between the measurement result and the reference value obtained by the highly accurate Vernier calipers, it is proved that the measurement system with the LVDT is applicable to the test of the moving part of the mechanism with better accuracy.

"Mechanism - hydraulic Co-simulation Research on the Test Bed of Gun Recoil Mechanism" this paper describes the test bed of recoil mechanism, recoil mechanism completed the recoil and counter recoil process, pushed by hydraulic cylinder. The test bed consisted of the mechanical system, the hydraulic system and the electrical system. The dynamic model and hydraulic system model of test bed were respectively built. On the basis of these models, mechanism hydraulic co-simulation model of test bed was built, and co-simulation analysis was developed. The movement curves of piston rod and pressure curves of accumulators were obtained. The study will provide a theoretical basis for the engineering application of test bed.

"Redundant stiffness absorbing system for redesigning of recoil forces profiles" this paper describes serial and parallel combination of wire rope absorbers junctions provide better absorbing of shock forces and external impulses. This performance is acceptable to be taken for different purposes including recoil force dumping. Paper considers relations of deviation caused by nonlinearities and hysteretic behavior as consequence of absorbing energy dissipation. This hysteretic behavior orientated threshold displacements required in application of this system to be employed in the design of composed hydraulic and wire rope weapon barrel brakes and recuperators. Main experimental parameters represented differences of mentioned serial and redundant junctions. Performances are estimated based on experimental static tests realized in this paper. Attempt of comparison with ideal elastic model is also performed.

VI. PROBLEM IDENTIFICATION

Today's artillery weapons may fire about one-quarter of the time and spend about another quarter of the time in moving about the battlefield. The remaining time is spent resolving RAM-D (reliability, availability, and maintainability durability) problems. The problems arises in conventional recoiling system are as follows –

- Specialization required in manufacture, leading to high cost and some difficulty in procurement; although it lends itself to mass production, fitted or select assembly is usually necessary.
- Maintenance in storage requires great care to avoid deterioration and damage by internal corrosion, particularly with leather packing.
- Variation of gas pressure with ambient temperature affects recoil velocity and distance. This may require some form of compensation.
- Greater number of internal cylinder walls requiring accuracy of form and high surface finish. Dents or scratches in the inside walls cause rapid failure of the packing passing over them.
- Difficulty of maintaining high rate of fire because of effect of heat on packing's and antifriction metal.
- Inadequate fluid reserve may allow the gun to fall out of battery at high elevation.
- Control rod is not positively tied to the gun; therefore its correct position is not inherently assured.
- Repairs require special facilities and expert mechanics.
- The recoil and counter recoil cylinders require separate filling.

VII. CONCLUSION

After studying various papers it is observed that work done on vacuum damped recoil system is not done, in most of the papers work is done on conventional i.e. hydro-pneumatic, spring type and on M.R dampers. Here attempt is made to overcome the problems arises in conventional recoil system by developing vacuum damped recoil system. For vacuum damped recoil system mathematical model is formulated to predict response of system. Mathematical model usually describe a system by a set of variable and set of equation that establish relationship between the variable.

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