Experimental Performance Analysis on Recoil Pad for Reducing Firing Shock Force

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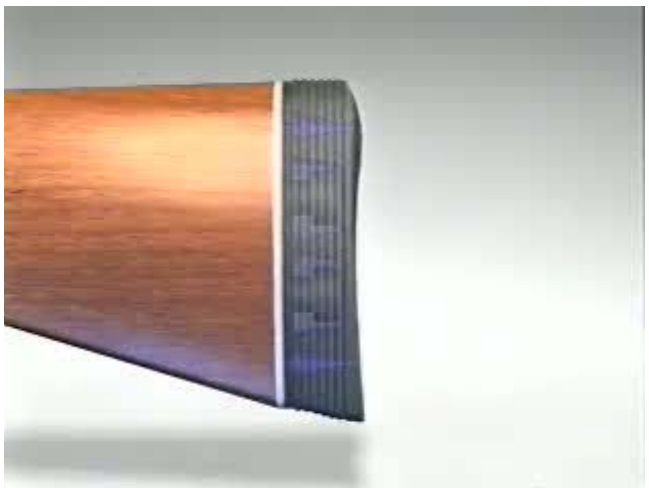
Introduction

- Recoil (Kick)
  - ✓ Physical property acting on rifle by firing
    → Momentum of rifle = Momentum of projectile + Momentum of powder gases (*Newton's third law of action-reaction*)
  - ✓ Firing shock force (*N*), recoil energy (*J*), impulse ($N \cdot s$)
    → Proportional to powder & gases quantity, exhausting gases velocity, muzzle velocity, projectile mass
    → Inversely proportional to rifle mass
  - ✓ Felt recoil
    → Related to peak pressure on the skin, which is caused by stopping the recoiling rifle
    → Items such as recoil pads, muzzle brakes and shock absorbers are utilized to reduce the amount of felt recoil.

Introduction

- Recoil Pad
  - ✓ Protect shooters from shock and vibration caused by firing.
  - ✓ Minimize recoil transmitted to shooters, which allows them to operate longtime with comfort.
  - ✓ Help shooters to aim at the target and fire precisely.



Research Background

- Experimental Prototype of New Rifle
  - ✓ Shoulder-fired dual barrel weapon system which consists of 5.56 mm and 20 mm caliber barrels
  - ✓ However, firing a 20 mm ammunition produces high recoil.
    → negative impact on the shooting performance
  - ✓ To reduce the total weight, recoil pad is used to reduce the high recoil of the weapon so that the soldier can fire the 20 mm ammunition precisely at the target without hesitation.

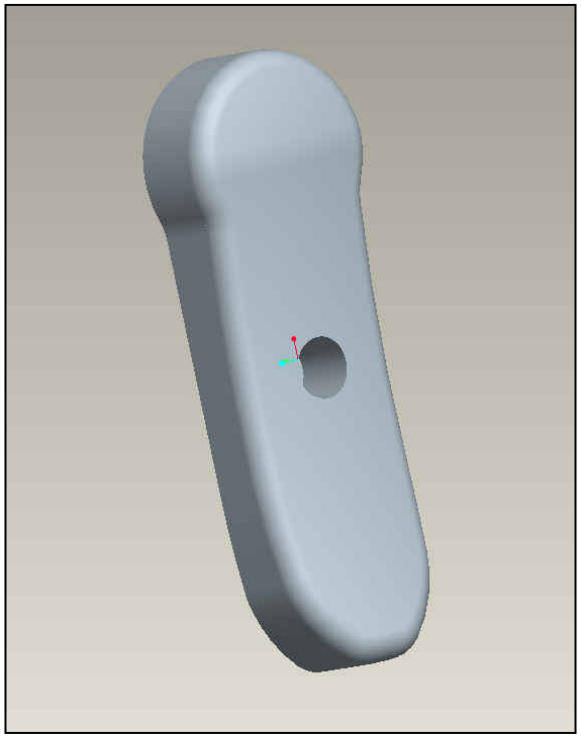
Mockup of New Rifle

Objectives

- Test and evaluation of the performance of recoil pads
  - ✓ Criterion : recoil-related firing shock force
  - ✓ Design variable : material property (hardness)

- Development of experimental setup for recoil pads
  - ✓ How to measure firing shock force, transmitted through the buttstock and recoil pad, while the rifle being fired on the sliding gun mount

Shape of Recoil Pad to be Tested



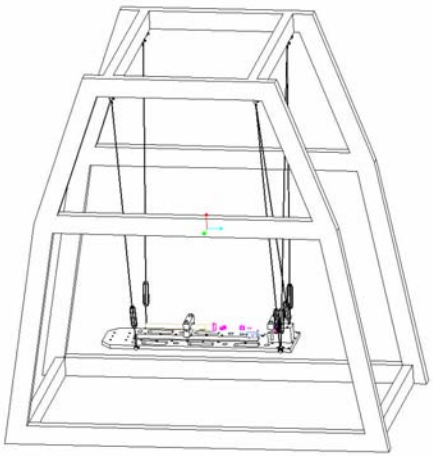
3D ProE Model

Recoil Pad

✓ **Designed and manufactured to be fit for the contour of shoulder area on which the rifle is rested.**

Impulse-Recoil Measurement

- TOP 3-2-826 (kinetic tests for small arms)
  - ✓ Measuring the impulse (I) and recoil energy (E) of small-caliber weapon by means of ballistic pendulum



4 Supports – 6 Wires System

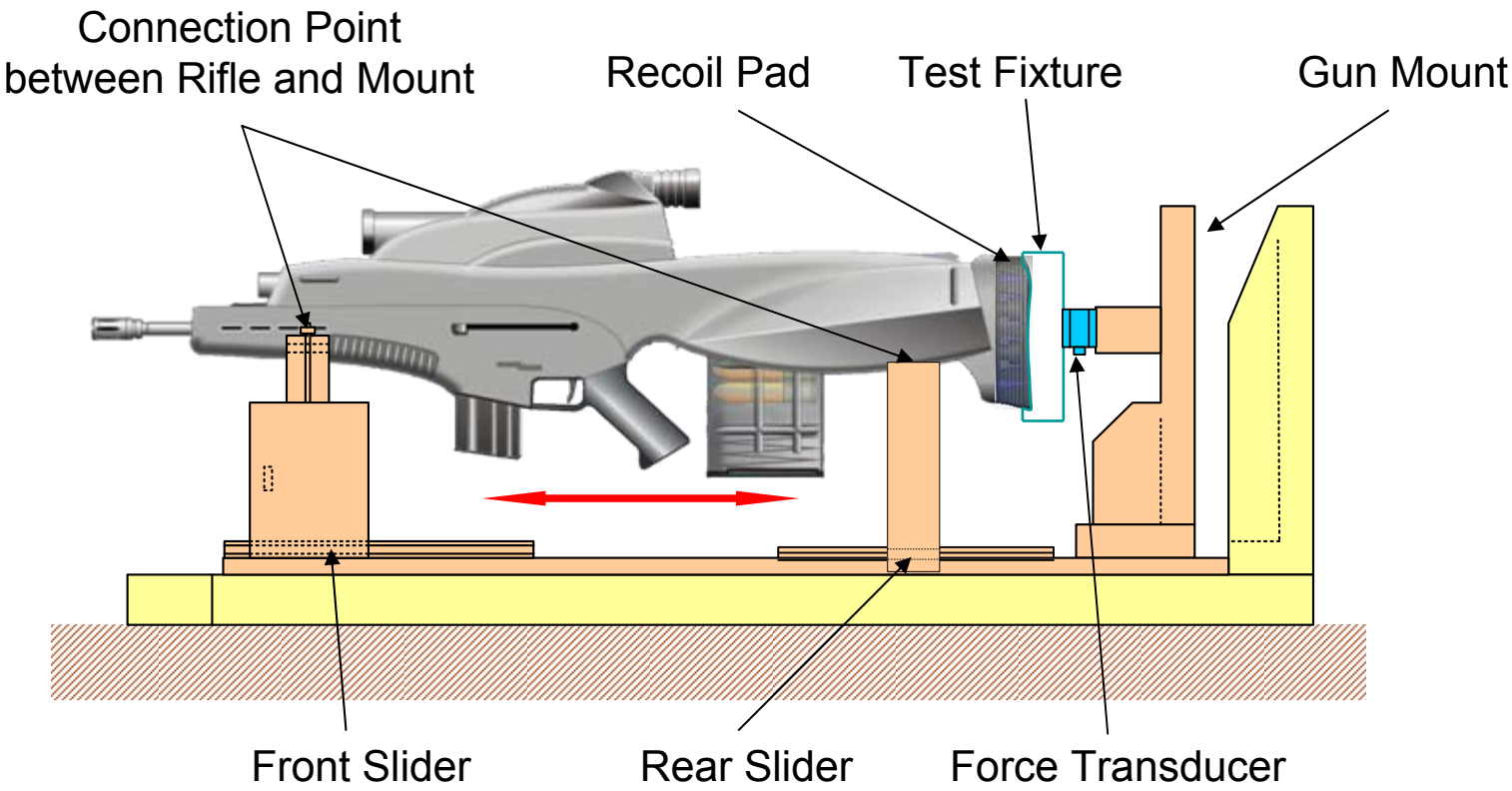
$$I = \frac{2\pi\left(m_{rifle} + m_{cradle}\right)d_0}{T} \quad (N \cdot s)$$

$$E = \frac{I^2}{2m_{rifle}} = \frac{1}{2}m_{rifle}v_{rifle}^2 \quad (J)$$

Intrinsic recoil-related values of rifle (irrespective of recoil pad)

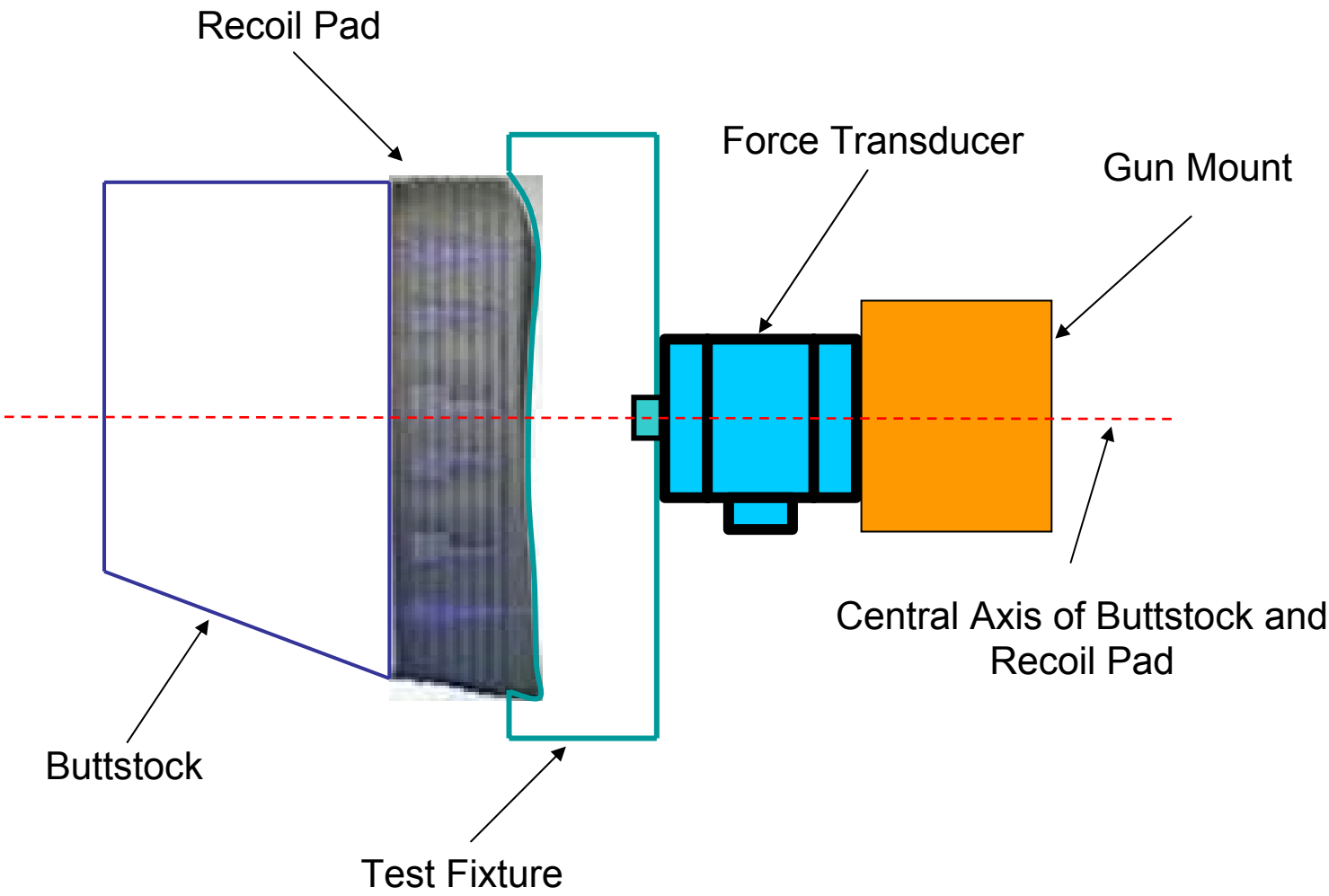
: The performance of recoil pad can not be evaluated by ballistic pendulum.

Experimental Setup with Recoil Pad

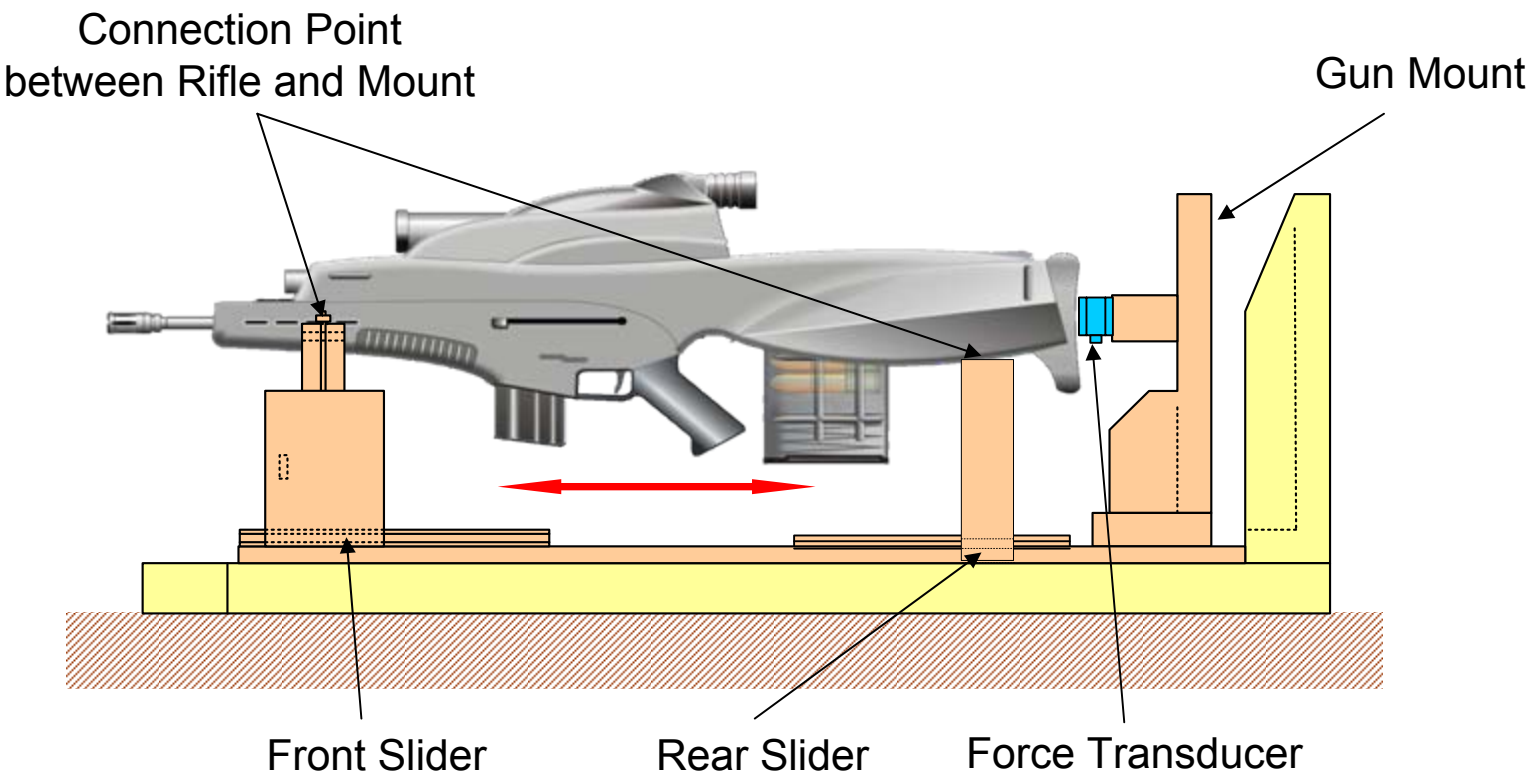


✓ **The rifle moves horizontally on the sliding gun mount.**

Experimental Setup with Recoil Pad

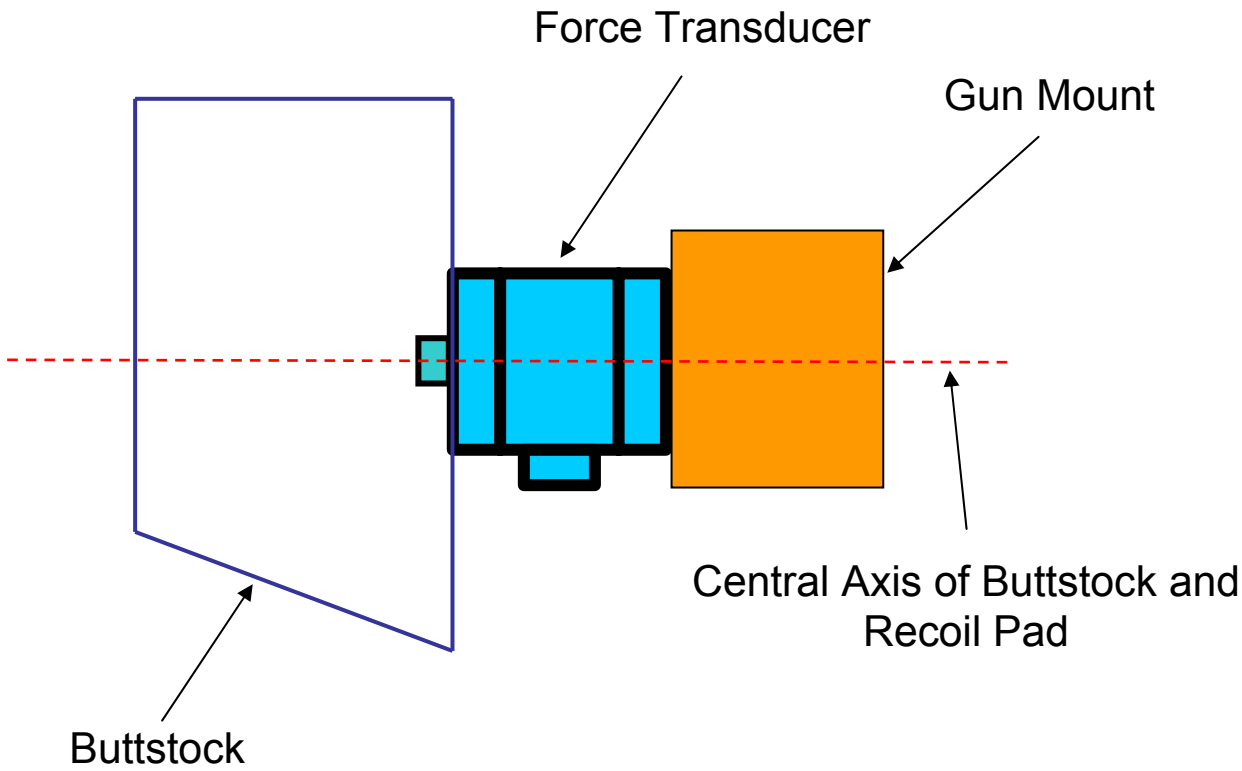


Experimental Setup without Recoil Pad

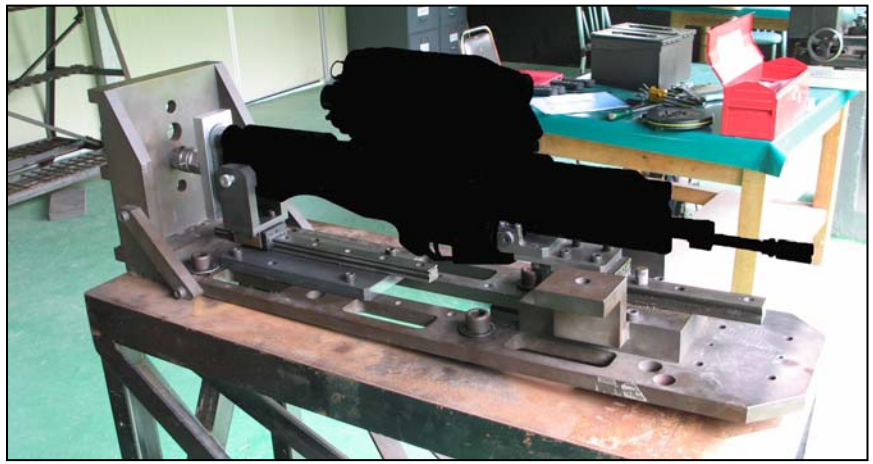


✓ **The rifle moves horizontally on the sliding gun mount.**

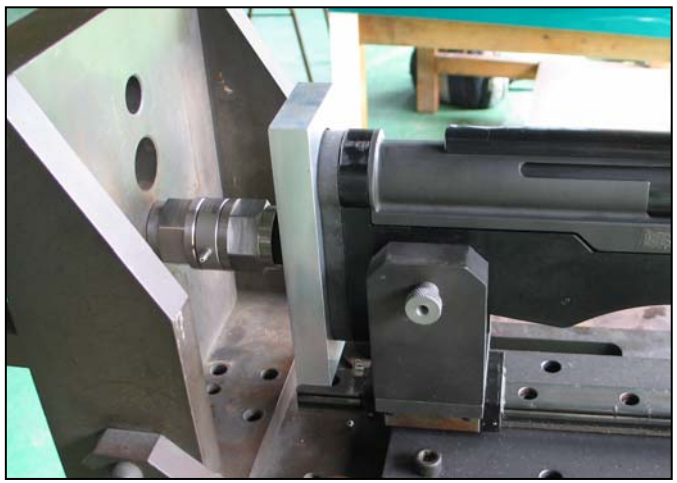
Experimental Setup without Recoil Pad



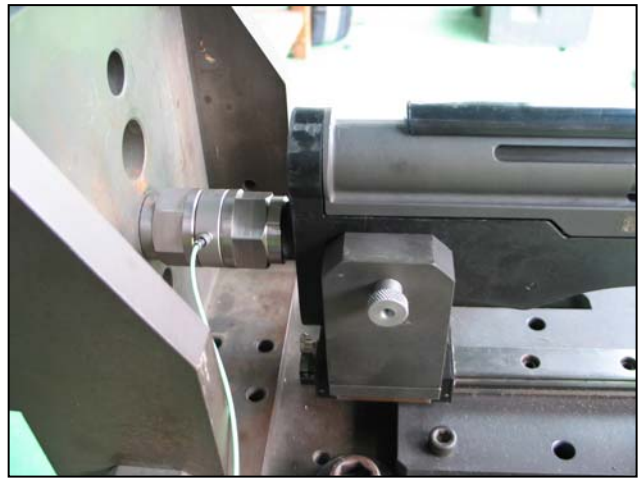
Experimental Setup



Experimental Prototype on the Sliding Gun Mount



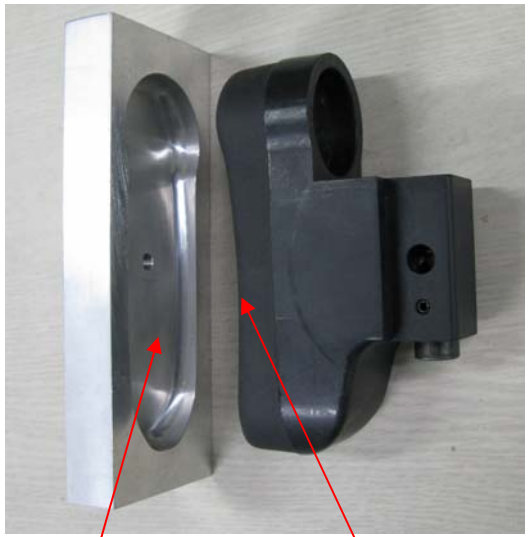
With Recoil Pad



Without Recoil Pad

Experimental Setup

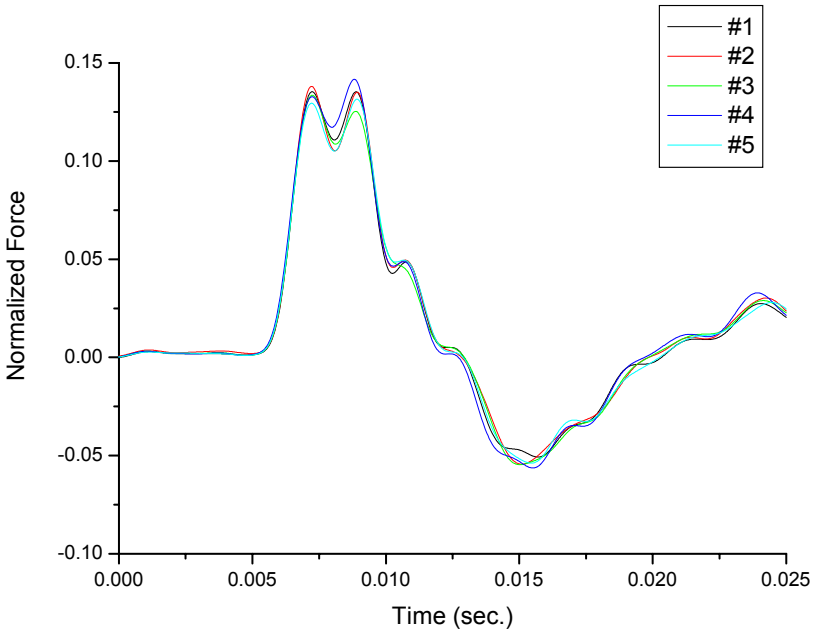
Test Fixture



- ✓ **Material of test fixture : Aluminium**
- ✓ **The inner curved surface of test fixture was manufactured to be perfectly matched with the outer curved surface of recoil pad by using NC machine and 3D contour data from 3D ProE model of recoil pad.**
  → The pressure, exerted by the recoil force, is distributed evenly on the whole contact surface.

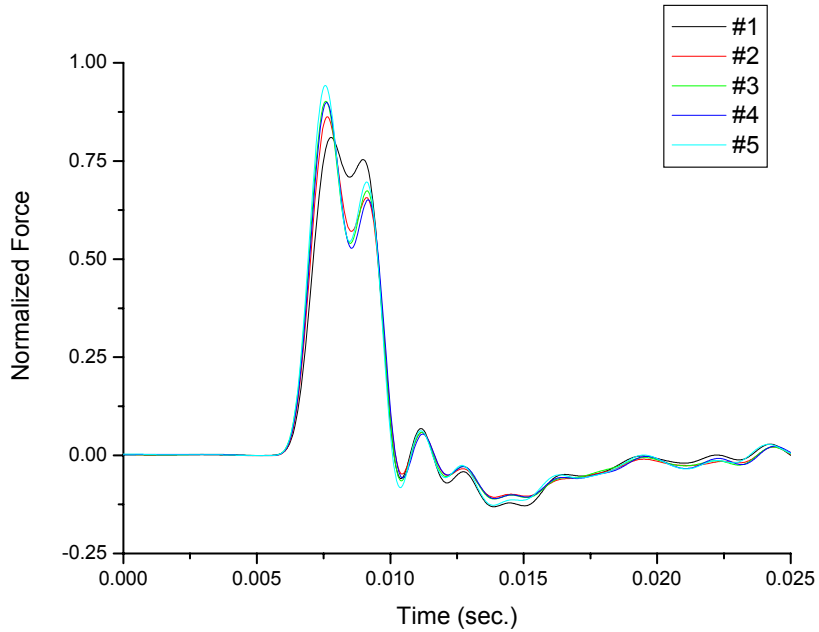
Experimental Results without Recoil Pad

□ Measured Firing Shock Force



In case of 5.56 mm ammunition (5 shots)

Peak firing shock force = 0.136F_{ref}

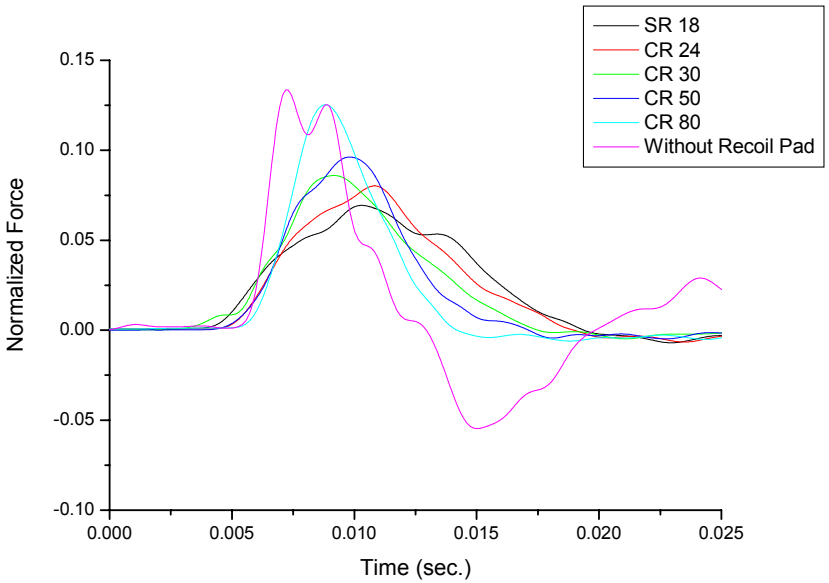


In case of 20 mm ammunition (5 shots)

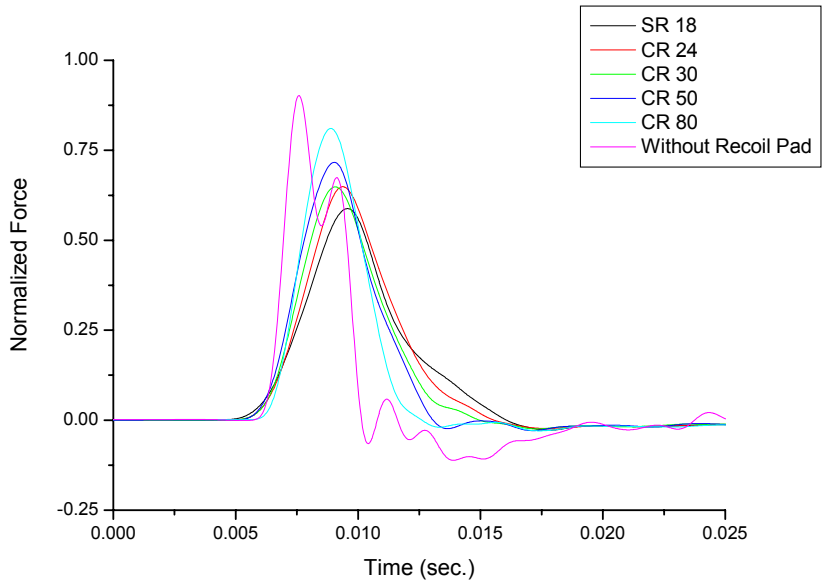
Peak firing shock force = 0.883F_{ref}

✓ **Peak shock force of firing 20 mm ammunition is around 6.5 times higher than that of firing 5.56 mm ammunition.**

Experimental Results with Recoil Pad



In case of 5.56 mm ammunition



In case of 20 mm ammunition

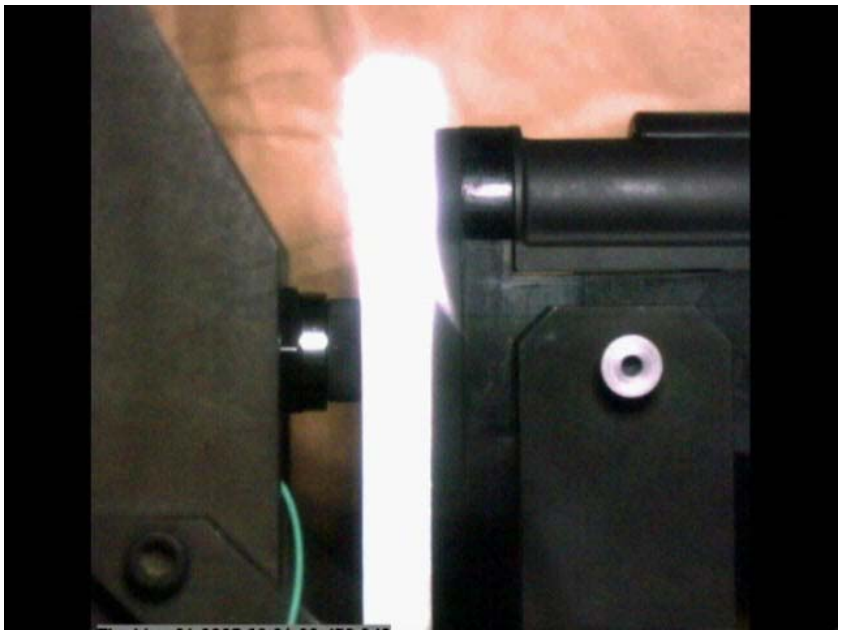
Peak Firing Shock Force (x F_{ref})

Material (Hardness)	SR (Hardness 18)	CR (Hardness 24)	CR (Hardness 30)	CR (Hardness 50)	CR (Hardness 80)	Without Recoil Pad
5.56 mm	0.068	0.081	0.090	0.101	0.121	0.136
20 mm	0.588	0.645	0.689	0.715	0.778	0.883

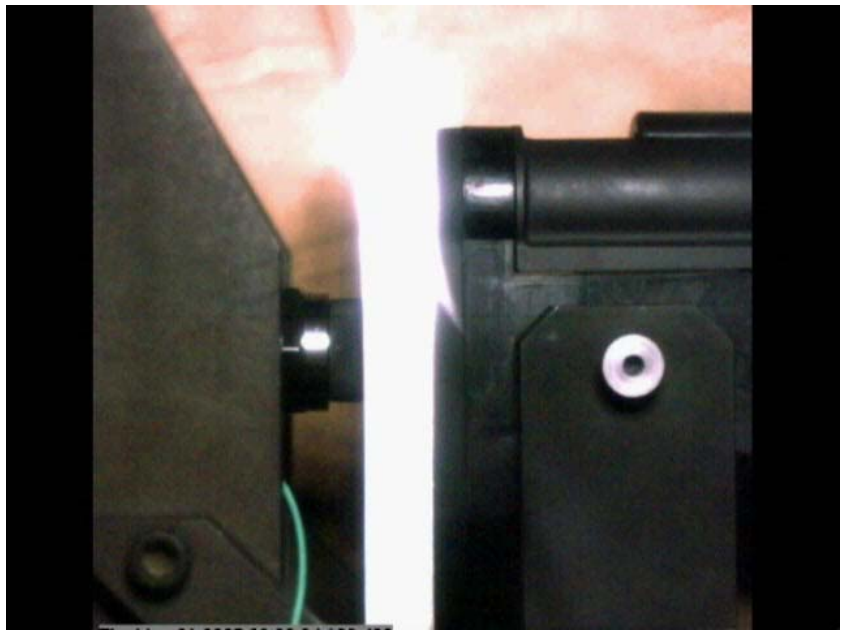
**** SR : Silicone Rubber, CR : Polychloroprene***

Experimental Results with Recoil Pad

- Motion of Recoil Pad by High Speed Camera



In case of 5.56 mm ammunition



In case of 20 mm ammunition

Summary

- Effect of the Hardness of Recoil Pad
  - ✓ The performance of reducing firing shock force was increased as the hardness of the recoil pad was lowered.
  - ✓ In case of SR(hardness 18), the peak firing shock force was reduced by 50% in case of 5.56 mm ammunition and 33% in case of 20 mm ammunition, respectively.

- Experimental Setup to Evaluate the Performance of Recoil Pads
  - ✓ It can be referred for the test and evaluation of recoil pads which will be attached to shoulder-fired weapon systems with high recoil, developed in the future.

End of Presentation

Thank you very much!

Contact Information

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