Firing Pin Impact Studies

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Introduction

The impact delivered by the tip of the rifle's firing pin to crush the primer pellet against its anvil is critical for the accuracy of a target rifle. The tip of the pin must be coaxial with the axis of the primer pocket and the flash hole. The kinetic energy of the firing pin assembly must be the correct amount and must be delivered consistently under all conditions. As Maj. Gen. J. S. Hatcher reported in *Hatcher's Notebook*, Stackpole, 1947; in acceptance testing, *all* military 30-caliber primers *must* fire when **60 inch-ounces** of kinetic energy (**KE**) is properly delivered to them, and *none* should fire at **12 inch-ounces**. Modern hunting rifles are made with high-speed striker springs and should be expected to deliver about **100 inch-ounces** to the commercial primers used in current ammunition. Delivery of more than **120 inch-ounces** of **KE** would probably be excessive and counterproductive to accuracy. Modern primers *do* produce more chemical energy (and *increased* muzzle velocity) when struck with *slightly more* **KE** than the nominal **100 inch-ounces**.

Development

Neglecting friction losses for the time being, the potential energy **PE** stored in the cocked striker spring is just the cocking force **f(s)** *integrated* over the total cocking distance **s.**

By *Hooke's law*,

$$f(s) = k*s$$

where **k** is the spring constant, and **s = 0** at the relaxed length of the spring.

The potential energy **PE** stored in the striker spring as the cocking piece is retracted from point **a** to point **b**, through the distance **s = b-a**, is the *definite integral* of this function **f(s)** over cocking distance **s** from **a** to **b**:

$$PE = \int f(s)ds$$

$$PE = k*\int_a^b s\,ds$$

$$PE = (k/2)*(b^2 - a^2)$$

$$PE = [k*(b + a)/2]*(b - a)$$

PE = [Average Cocking Force F]*(Cocking Distance S).

As soon as the sear gets out of the way (and still neglecting friction), the Kinetic Energy **KE** imparted to the striker during its fall is:

$$KE = (1/2)*m*V^2,$$

where **m** is the effective mass of the striker and **V** is the terminal velocity of the striker.

But, the striker, starting from rest would accelerate its mass **m** to the same terminal velocity **V** whether the force driving it is *constant at its average* **F**:

$$F = [f(b) + f(a)]/2$$

or *varying linearly* from **f(b)** to **f(a),** so recalling Newton's Second Law in the form:

$$F = m*A$$

where **A = Average acceleration of the striker assembly**.

From physics, we know that:

$$V^2 = 2*A*S = 2*A*(b - a), \text{ and}$$

$$KE = (1/2)*m*V^2 = (m*A)*(b - a)$$

KE = (Average Cocking Force F)*(Cocking Distance S).

So, still neglecting friction:

$$KE = PE.$$

The effective mass **m** of the striker doesn't matter very much as far as the conversion of **PE** into **KE** is concerned. [The mass **m** divides out, so it cannot be zero.] The striker impact **KE** depends primarily on the spring constant **k** of the striker spring, its installed compressed length **s = a**, and the total striker fall distance (**S = b – a**) to impact with the primer.

Firing Pin Comparisons	Remington 700 Long Action	Tubb Speedlock
Striker Weight	**761.1 grains**	**317.1 grains**
Spring Weight	**202.8 grains**	**182.1 grains**
Effective Weight (**w**)	**862.5 grains**	**408.2 grains**
Average Spring Force (**F**)	**22 pounds**	**24 pounds**
Potential Energy (**PE**)	**102.8 inch-ounces**	**112.1 inch-ounces**
Average Acceleration (**A**)	**178.6 g's**	**411.6 g's**
Impact Velocity (**V**)	**16.72 ft/sec.**	**25.4 ft/sec.**
Lock Time (**T**)	**2.911 milliseconds**	**1.917 milliseconds**
Impact Momentum (**p**)	**1.025 oz-seconds**	**0.737 oz-seconds**
Impulse Force (**Q**)	**320.3 pounds**	**230.3 pounds**

Consistent primer ignition depends on reliably striking it with **KE>Threshold KE of 100 inch-ounces** in all firing conditions. Allowing for friction losses, something like **25 pounds** of spring force falling through about **0.3 inches** should be plenty of **KE** (up to **120 inch-ounces**).

I like to minimize the momentum transfer to the cartridge assembly by using an aftermarket striker assembly having about *half* of the effective mass of the factory Remington 700 striker. It will not be as likely to set back the case shoulders (and thereby increase the headspace) or to reseat the bullet deeper. Also, lock time is reduced by **35%**, and that is always an improvement.

The enclosed table shows a comparison of all of the physical variables which could be examined in choosing between using a factory ***Remington 700*** long action striker system versus using David Tubb's ***Speedlock Systems*** replacement striker assembly in a target rifle. The low-mass aftermarket spring is only slightly stiffer than a new, uninstalled factory spring, but it is claimed to hold its stiffness much longer. The factory spring is weakened by simply installing it.

The striker fall **S** is the same **0.292 inches** in either case. The Effective Weight **w** is calculated as the Striker Weight plus **one half** of the Spring Weight. Similarly, the Effective Mass **m** (in slugs, or pounds-seconds squared per foot) is the Effective Weight **w** of the striker assembly (in grains) divided by **7000 grains per pound** and **32.16 feet per second per second** as the acceleration of gravity **g**.

$$S = b - a = 0.292 \text{ inches}$$

$$m = w/(7000*g).$$

The stored Potential Energy **PE** is found from:

$$PE = F*S.$$

The Average Acceleration **A** is found from:

$$A = F/m.$$

The Impact Velocity **V** is found from:

$$V^2 = 2*A*S.$$

The Lock Time **T** is found from:

$$T^2 = 2*S/A.$$

The Impact Momentum **p** is found from:

$$p = m*V.$$

And finally, the Impulse Force **Q** is calculated as:

$$Q = p/dT,$$

where **dT = 200 microseconds** (a *roughly estimated value*).