Recoil

ONE OF THE MOST DISCUSSED – AND LEAST UNDERSTOOD – SUBJECTS IS RECOIL. TO GET THE COMPLETE STORY WE ENLISTED THE HELP OF DR. ROBERT BIRCH, AN EXPERT ON THE SUBJECT AT THE IMPACT RESEARCH CENTRE OF LIVERPOOL UNIVERSITY'S DEPARTMENT OF ENGINEERING IN ENGLAND

Most shooters know that recoil means to be pushed backwards by the shotgun during firing. Sometimes the meaning of recoil is misunderstood; so let's agree that a gun recoils and we react to it. The kick that we feel, is in fact, a recoil reaction. Recoil and recoil reaction are related but they are not the same thing – even their units of measurement are different.

It is not generally understood that the recoil process begins immediately on firing, after the shot moves forward from the cartridge inside the chamber. This is because the high pressure gas of the burning propellant forces the projectile to accelerate along the barrel until it exits at the muzzle. Of course, at the same time, this gas pressure acts backwards against the gun to produce recoil (action and reaction).

Imagine if we suspend the gun by wires from the ceiling and fired it very carefully so as not to disturb it in anyway, then we would see the gun swing backwards a considerable way. An even better test would be to fire the unsupported gun in the frictionless vacuum and near zero gravity of outer space, so that we would see both gun and projectile move off in opposite directions at constant velocity

for eternity — or until we halt them that is.

To stop the gun we must apply a braking force to the butt and we can choose to brake either quickly or slowly depending on what we need to do. The rate at which we stop the gun (deceleration) depends on the force applied to the butt — faster braking requires a higher force.

In reality, when we fire the gun, our shoulders (and other parts of the upper body) apply the braking force necessary to stop it in time for it to be moved forward into the ready position again. If we try to do this faster, then we need to apply a larger braking force.

Generally, when taking a shot, we don't make a conscious decision to use any particular braking force. In fact, it is largely determined for us by a set of parameters over which we only have limited control. Therefore, the braking force which we apply to the gun through our shoulder, hands and arms is a reaction to gun recoil – so let's agree to call it a recoil reaction force (or simply the reaction) to signify the difference from recoil itself.

Even when the shot has left the barrel (and for some time afterwards) the high pressure gases escaping from the muzzle, together with the inertia in the rearward gun motion, continue to push the butt into the shoulder. Reaction is dependent on a number of parameters such as the stature or build of the shooter, mass (weight) of gun, type of pad or clothing, ammunition and, of course, whether or not a recoil reduction system is used. A higher or lower reaction force occurs with respect to a variation in any one or combination of parameters such as these.

MEASURE THE FORCE

Recoil is simply the maximum energy (foot-pounds [ft. lb.] in imperial units or Joules [J] in modern SI units) attained by the gun after firing a shot. Methods of measuring recoil and attempts to standardize it have been going on for over a century and authors such as W. W. Greener, Major Gerald Burrard and Major General Julian S. Hatcher have written much on the subject. Measurements like the pendulum gun, gun rest and spring dynamometer relate recoil to how much a gun moves backwards and they are still in use today. More sophisticated tests, using dynamometers with electrical sensors, began in the 1920s as part of the quest for ever more accurate and lighter military rifles.

The human sensory system is not equipped to sense energy and so a recoil measurement is only an indication of what reaction a shooter can expect to feel when taking a shot with a gun. Our nervous system reacts instead to an applied force, which is expressed in units of pounds force [lbf] or Newtons [N] in SI metric. A large recoil would only indicate that we should expect a large reaction at the shoulder.

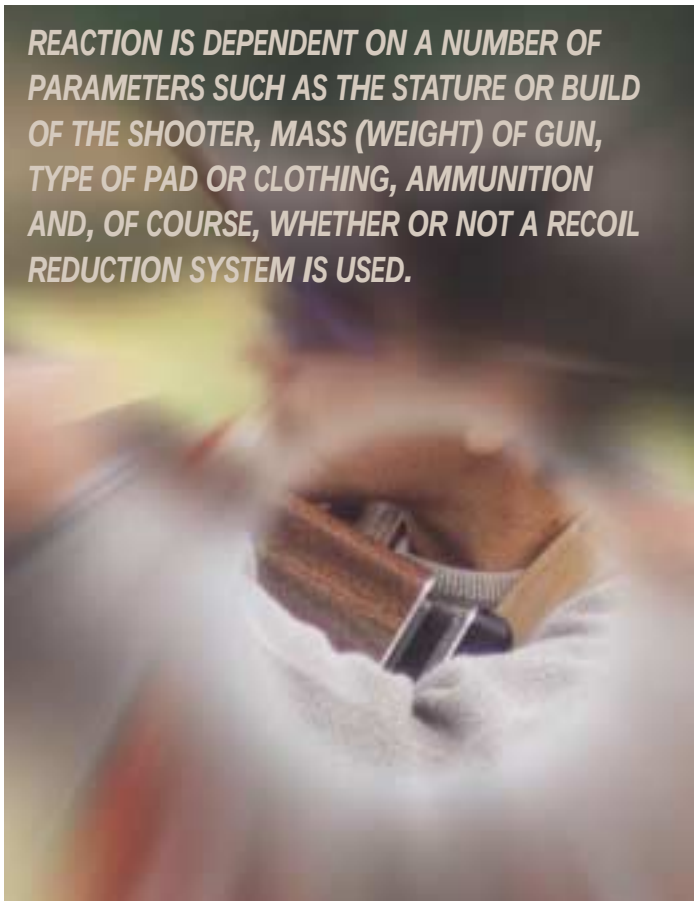
Today, specially designed high-speed transducers are fitted onto the stock in order to measure and record the actual reaction force between shoulder and gun. Test results from this show that the reaction force varies considerably during a shot and is not just a simple push into the shoulder but a complex series of pulses occurring over a fraction of a second. Unfortunately, our nervous system is not sensitive enough to distinguish between these individual force pulses, which we perceive to be a single kick.

As soon as the gun is fired the reaction force increases rapidly against the shoulder to a peak value. This peak reaction force quickly falls off, but may be followed by several lesser peaks and troughs before returning to the pre-shot level again. The whole recoil event for a shotgun is completed in about 1/40 of a second. We can simplify things and talk about the reaction in terms of an equivalent mean or averaged force acting for the same amount of time as the 'real' recoil. Typically, a mean reaction force delivered to the shoulder (per shot) from a 12 gauge shotgun using standard 28gm load cartridges is about 350 N (approx. 80 lbf) but the peak force may be around 1200 N (approx. 270 lbs force) or higher – more than three times greater than the mean. If 1200 N force (equivalent to nearly five 56lb. sacks of potatoes) were to be applied slowly to your shoulder then I'm sure most of us would become uncomfortable very quickly. However, the peak acts for a considerably shorter time than the total recoil process itself; less than the blink of an eye in fact, and the body reacts in a different way to this kind of stimulus.

To consider only the 'mean' force of the reaction is a gross over simplification. Only by accurately recording and analyzing the rapid recoil pulse can we begin to understand the complex interaction between gun and shooter. The reaction is unique to the particular shooter and gun combination so that we can idealize it as a recoil signature, with no two shooters being alike.

MORE KICK

Higher velocity cartridges of the same shot load will produce a higher reaction force at the shoulder. But, even when the velocity of two entirely different



cartridges is similar, shooters may perceive a difference in kick. The explanation is usually found in the signature, which could have the same mean value but a completely different set of peak forces. Peaks in the signature contribute significantly to the difference in 'feel' between cartridges. Faster burning powders are one cause for this as they produce higher barrel pressures more rapidly than a slower type even though the two may have equal amounts of energy.

GUN WEIGHT

The so called conservation of momentum theory applies here, which states that the mass (weight) of the projectile multiplied by it's velocity must equal the mass of the gun times it's rearward velocity. So if we increase gun mass there must be a reduction in rearward velocity. Therefore, if we can reduce gun velocity then we reduce the reaction (braking force) necessary at the shoulder to slow it down and bring it under control. Near zero recoil could be achieved with a very heavy gun mass but clearly, for practical reasons, there needs to be a trade off between good handling and recoil reduction.

In practice, the mass of a gun can be increased by including the mass of the shooter's arms (plus a fair portion of the upper body) through having a good grip with the hands and ensuring correct placement of the butt into the shoulder. A correctly fitting gun is important.

RECOIL EFFECTS

Unlike other joints in the human body, the shoulder is not a simple ball and socket but a complex mechanism, which is made up of several bones that move together as a whole in order to provide the necessary articulation. Several muscle groups are used to actuate the shoulder and two important ones are the pectoralis major and minor that cross over each other (major over minor) to form a convenient pad of tissue on which we place the butt of a gun.

As we mount the gun in readiness to fire, the shoulder holding the stock is articulated in such a way that the pectoralis muscles are in a relaxed state and, when the gun is fired, the recoil applies a localized impulse pressure that tries to stretch them. The human body is not passive and if a force stimulant is severe enough then self-preservation takes over and an involuntary reflex reaction occurs over which we have only partial control. The process of stimulation and response takes time and does not come into full operation until well after the shot has left the barrel. Therefore, during a shot, the human body can do little to defend itself and we are open to the full attack of the recoiling gun.

The long term accumulative effects of recoil on shooters are not well documented and so it would be foolish to suggest limitations on the amount of shots we should make per day, week or year. For sure there is a diversity of injuries from simple headaches, bruising and backache to broken shoulder bones but, as you will now understand, there is an equal diversity of shooter and gun combinations that may be to blame.

There is no simple answer to the question of accumulative effects of recoil and how best to assess it. It is likely that a significant contribution to any discomfort and injury is due to the peak force in the early stages of the reaction. This catches our nervous system off guard well before our reflex has time to operate and can set up serious shock waves in the arms, shoulder and back; high-speed cine recordings confirm this.

Like all physical sports involving impact or impulse, there are methods to minimize the risk of injury. In the absence of defined criteria we must take a common sense approach and consider all aches and pains as being early warning signs of something we are doing wrong in shooting. Appropriate action must be taken sooner rather than later and, certainly, a proper gun mount and stance can make an immediate improvement in comfort.

The peak force, mean force and duration of the reaction are important factors for comfort and safety. Methods such as using muzzle brakes or low velocity cartridges tackle the problem at source by reducing the recoil itself. If this is not practical then the use of either a proper recoil pad, mechanical absorber or a heavier gun will all have some effect to reduce recoil reaction forces.

A WELL FITTED GUN, GOOD GRIP AND THE CORRECT PLACEMENT OF THE BUTT INTO THE SHOULDER CAN HELP REDUCE THE EFFECTS OF RECOIL. OUR TWO PICTURES HERE, OF ANTHONY MATARESE JR, ILLUSTRATE THE POINT – BUT ALSO NOTE THE LACK OF TENSION IN THE RIGHT ARM AND HAND.