



## New 3D cad design semi automatic kinetic system hunting and sport shotgun prototype production and testing studies

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### Abstract

Due to the development of the technology, the use of alternative materials and the installation in accordance with the current market conditions, less maintenance and cleanliness, less cost of production and a more economical part due to less component and therefore simple mechanism principle, reduced number of parts-based breakdown, 12 gauge caliber hunting and sports shotgun with semi-automatic kinetic system were developed and designed in Creo 3.0 3D solid model program. The prototype and front series were subjected to shot tests in accordance with the TS 870 standard. According to the test results, the design has been removed from the negativity and the production information package has been formed so that the developed serial production can be done.

**Keywords:** Creo; 12 gauge; kinetic system; semi-automatic hunting rifle; TS 870.

### 1. Introduction

Firearms develop out of the use of potassium nitrate which is come out by the decomposition of some organic waste materials, as a combustible explosive substance with some mixtures. When the first appearance of the gunpowder is examined, it is seen that gunpowder is not used both as a war tool and as a flammable material. It came out as a result of the researches that the Alchemists done with supernatural belief to find out the potion of every important thing in life. The centralist minded rulers of the time, who were seeking for easier attack and defense methods against their enemies, were not considered to use of explosive, flammable and launching capability of the gunpowder which is a mixture of potassium nitrate and sulfur and charcoal as a warfare tool. We can say that the discovery of the contemporaneously black gunpowder and cannons which is a primitive form of the firearms, coincide with the same turn. Before the gunpowder emerged as a weapon, it was known that it had been used for various purposes for a long time, as a flammable and a noise generator by the Chinese. But it is known that since the beginning of the XIII. century, the Chinese have used the earliest specimens of cannons with gunpowder to produce horrible voices and flames also they have thrown the masses made up various hard particles mixed with gunpowder which they put into thick paper for the purpose of bombs to

their enemies by hand or catapults. The Chinese knew that the gases that emerged after the expansion of the gunpowder had thrown various objects, as well as shrapnel-like particles placed in these objects for a long time. It was not took too much time to use cannonball throwing apparatus via gunpowder filled metal pipes. When the traders and the travelers that were traveling to the exotic east return to their countries and tell what they see, Europeans also describe the flaming and explosive nature of the gunpowder in the XIII. and XIV. centuries after the Arabs, the Mongols and the Indians. The process of setting up the bolt is generally all the events that take place in order to prepare the next gunshot to fire the gun. Based on the setting up process it can be grouped under 3 title;

Because the operation of the cannon is also based on the system of launching the bullet in the tube shaped barrel at a high velocity with the gases generated as a result of combustion. A firearms is generally named as a tool which is capable to shoot a bullet which might have a special shape and material to a target is made of at long distances. [1] Firearms generally have a mechanism that contains a barrel, firing pin, hammer and trigger parts. (Figure1.1.) [2].

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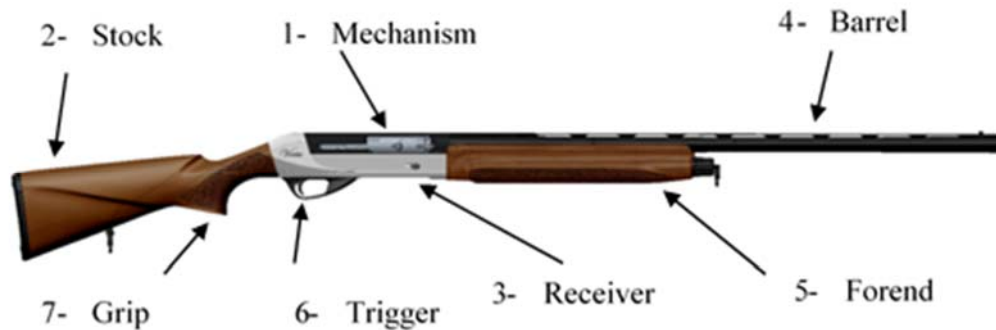


Figure 1. Shotgun.

Working mechanisms of most firearms are similar to each other. A firearm is being loaded with a bullet, and then fired by pulling the trigger. Loading is being performed by compressing the recoil spring and by retracting the firing pin or hammer. By pressing the trigger a pin which holds the retracted firing pin releases the firing pin and recoil spring. Firing pin hits the primer on the case which is located in the chamber, and this creates a spark for firing. The spark moves forward from spark fires the powder. Powder burns out very fast. This situation creates hot gases under high pressures. After the pressure reaches a certain value, pressured gasses force the bullet move away from case very fast. This system is same on all firearms. A hunting and sporting shotgun has a straight barrel which shoots. Shotshell shots, by coming from shoulder. Sporting, hunting and defence shotguns are being classified by quantity of barrels, loading and extracting style and shotshell capacities.

Another definition can be named as shotguns which are being used at long hunting and competitions with either shotshell as a single bullet. Generally, unrifled hunting rifles are being used for hunting small land

animals [3].

The process of setting up the bolt is generally all the events that take place in order to prepare the next gunshot to fire the gun. Based on the setting up process it can be grouped under 3 titles;

- Manual set up; preparing the bolt via hand to the other shot after the firing.
- Semiautomatic; preparing the other shot using various methods by the system itself without the help of the user.
- Fully automatic; this system is a system that continues to fire and self-establish until the finger is pulled from the trigger.

The type of setting systems of the semi-automatics in our project is also classified under 2 titles in hunting rifles;

- Gas system; systems that need gas feedback for setting up.
- Kinetic System; system that use the flareback force from the firing.

## 2. Semi-automatic hunting shotgun with kinetic system

Kinetic system works with the recoils forces coming from shooting to the internal mechanism of the firearm. When shooting happens, shotshells explodes and recoil forces moves the mechanism back words. By this way empty shotshell extracts and new shotshell is empty shotshell is being chambered by the movement of the mechanism. this system Works with the opposite pressure when firing. Based on the quantity of the system parts, kinetic systems has advantages. System does not require too much detailed parts, but balance of the internal springs and extracting forces are quite important. But if the shotgun is not backed up with a strong shoulder so that

the recoil forces may cycle the kinetic mechanism then system may not work properly. Dust, dirty causes the system not working properly on an uncleaned shotgun.

Cycle strats with recoil on kinetic systems. Recoil forces are being used to unlock the locking mechanism with kinetic energy. Reverse acceralation which caused by the recoil of the heavily designed mechanism weight of the mechanism which causes an inverse inertia to the acceleration direction stores tese forces on the pressure spring which is in front of the mechanism [1].

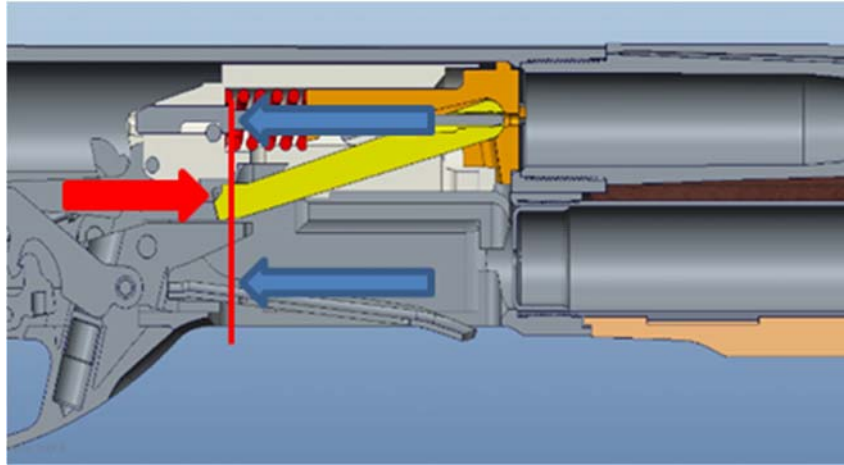


Figure 2. Working system of kinetic shotgun.

Acceleration of the mechanism caused by the recoil forces are important on kinetic system shotguns. Any deviation of acceleration causes sensitivity for cycling and requires precise manufacturing. Holding the shotgun constantly as supporting the buttstock to a fix point causes issues on the cycling of the shotgun. [4]. The arrows shown in blue on the figure indicate the acceleration direction of the shotgun recoil while the red arrow shows the direction of the inertia of the mechanism caused by acceleration (Figure 3).

The shotgun cycles very sensitive on low pressured

shotshells if the user holds the shotgun very constantly. On of the main issue on the manufacturing of the shotgun is capability of shooting a wide range of shotshells from low to high pressures. If the spring forces are adjusted to low pressures, then recoil forces become very high on high pressures. To be able to cycle the shotgun on low pressure friction forces coming from mechanism ports required to lower down by adjusting the surface roughness and coatings. Upper receiver is made out of 4140 grade steel with a 45-48 HRC hardness.

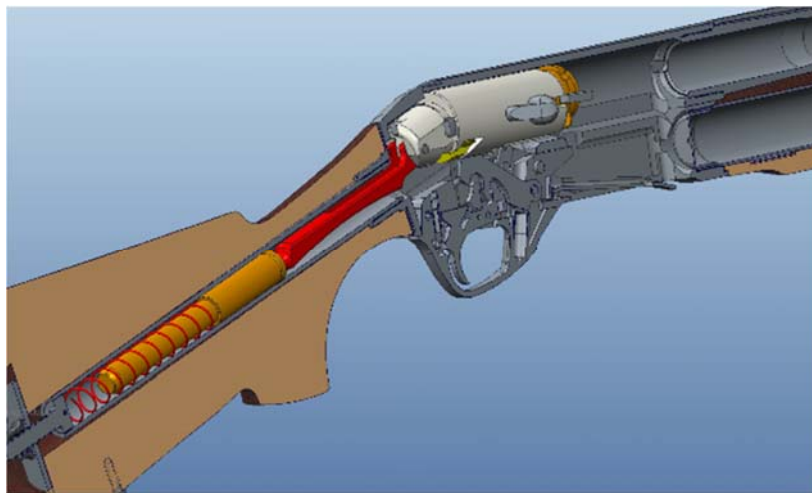


Figure 3. Mechanism pushing of closing system

Recoil spring tube is made out of 7075 aluminium instead of a 6000 series. This part has a 120-150 HB surface hardness and has better friction results by working with a steel roughness recoil spring plunger and recoil spring tube are made out of extrusion on the working directions. On most of the shotguns

aluminum upper receivers are being used. Relative low surface hardness of aluminum receivers and narrow surfaces causes risks on the life time on the shotgun. On our kinetic system shotgun a bore connection design was made and 4140 grade steel was used to extend the lifetime.

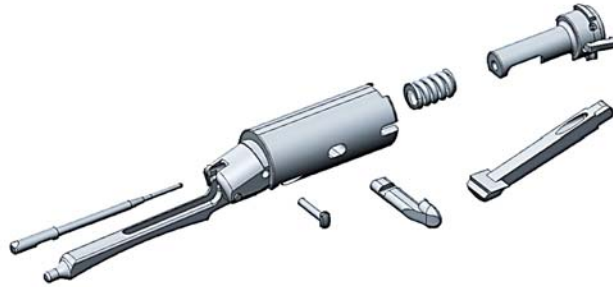


Figure 4. Mechanism group.

### 3. Designes and tests

Locking mechanisms are the key design details of different type of firearms. This is one of the main diversity between different systems. The purpose of the locking mechanism is to hold the pressure inside the barrel at certain time until the ammunition leaves the barrel so that the pressure fully accelerate the ammunition. Most of the kinetic shotguns on the market have locking system which operates with a cam pin mechanism on a rotating bolt and they travel on an aluminum frame and locks onto steel barrel extension (Figure 5).

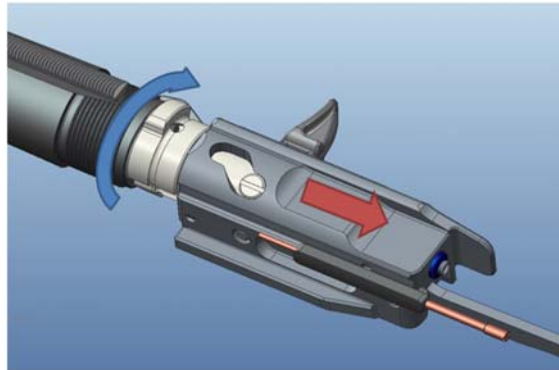


Figure 5. Turnover.

The rotary bolt opens the lock of the system by moving out of its locked position in the barrel extension with the help of internal inertia spring force [7].

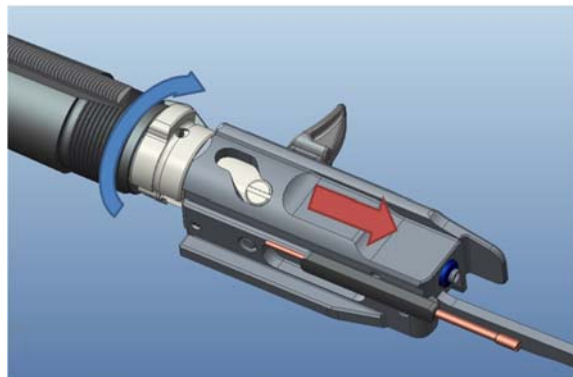


Figure 6. Locking.

In systems that operate like this way, the force required to open and close the lock is very high. It requires locking positions which is hard to manufacture. These precision measurements can cause the lock jam or high force requirements to open the lock. Due to the rotation motion high friction occurs in the cam and locking positions, therefore the system needs good surface quality.

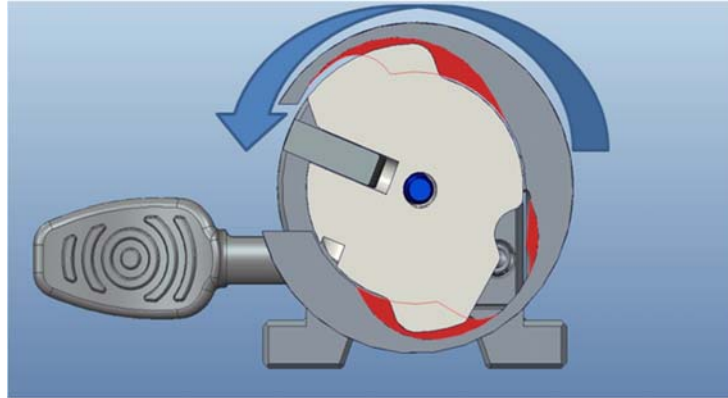


Figure 7. Opening the lock.

Unlike most kinetic systems in the market, locking is made by the lever in this project. The lever interlocks not the barrel extension but the AISI 4140 steel upper

body which also undertake the bearing of the rotary bolt [5].

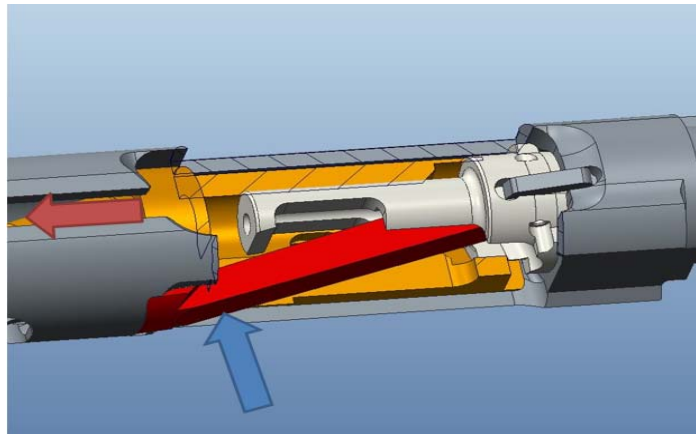


Figure 8. Locking position of the lever.

In the locking position of the system, the rotary bolt head and the locking lever does not move. The motion that comes to rotary bolt from the kinetic system allows the lock to open by getting out of the locking position on the upper body. The angular slot under the rotary bolt lifts the lock up and pulls it into the groove with the recall movement of the bolt. The bolt head is released by opening the lock and then the rotary bolt-lock-bolt head begin to move together and carry out the stages of unloading and then feeding (Figure 8).

The advantages of this system over the rotating systems are that creates low frictions, cost saving and

making manufacturing easy by not requiring precise tolerances and surface quality. Due to these reasons, the forces required to open and close the locking are lower. The lock design, which allows adjustment of the locking clearance, can be precisely adjusted by grinding it from the end. This system prevents the swelling of the shell due to the locking clearance between the bolt head - base wad and extractor skipping problem due to shell sticking in the barrel extension. In the market, the most of inertia driven shotguns have negative points such as on bolt locking system has friction and the difficulties during production (Figure 7).

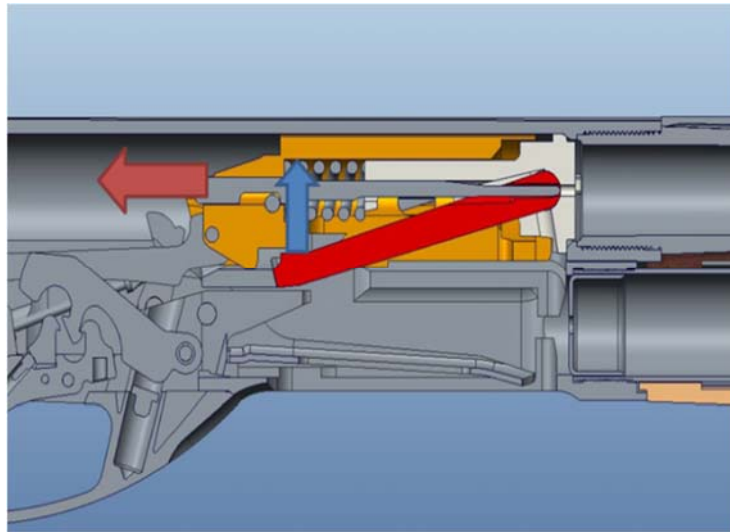


Figure 9. movement of locking slot.

The new locking system has been executed to avoid such kind of negative points. The linear active locking system has been applied to Project of inertia shotguns which needs less recoil energy to cock the mechanism rather than gas operated system, to intend minimum friction. The parts of mechanism has been produced from AISI4140 material and heat treated at high level hardness (+40 HRC) and coated with chrome to give more resistance on surface. The first design of feeding system has been changed in according to the feedback at during exhibitions.

At the first concept of the carrier latch moving back

and forward operates like cartridge feeder, but it is not possible to chamber the cartridge from the magazine tube by hand. Depending on the end users feedback, the cartridge loading part has been included and this part helps to load cartridge from the magazine tube to the chamber easily. In the design of Inertia driven shotguns have a problem to shoot with the several grams of shotshell loads and doing some work to increase capability of this variety. As stated above, Inertia system has low cocking forces to operate and this cause a problem to operate mechanism with 24 grams loads. (Figure 10)

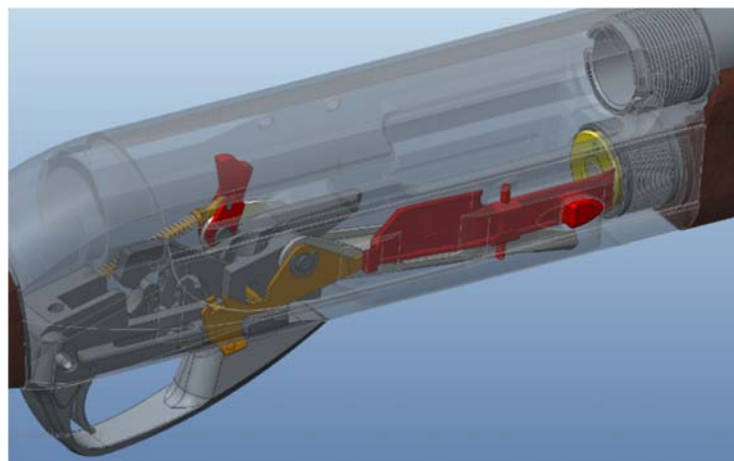


Figure 10. The appearance of a flask in a flare tube.

During the test period, malfunction has been seen at light shotshell loads caused by the mistake of user (Figure 11).

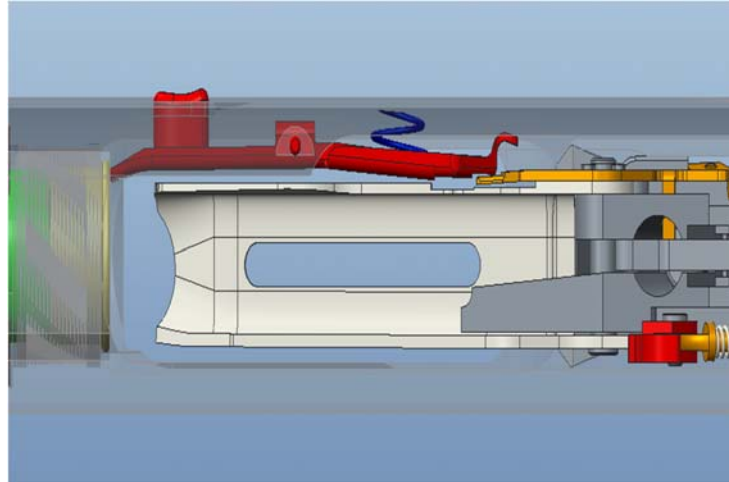


Figure 11. Status of the moment of firing the carrier holder and feeding hair.

When the user is holding the shotgun tighter at his shoulder and give more force to stock of shotgun than

inertia is reduced and the less recoil force cause malfunction at light shotshell loads (Figure 12-13).

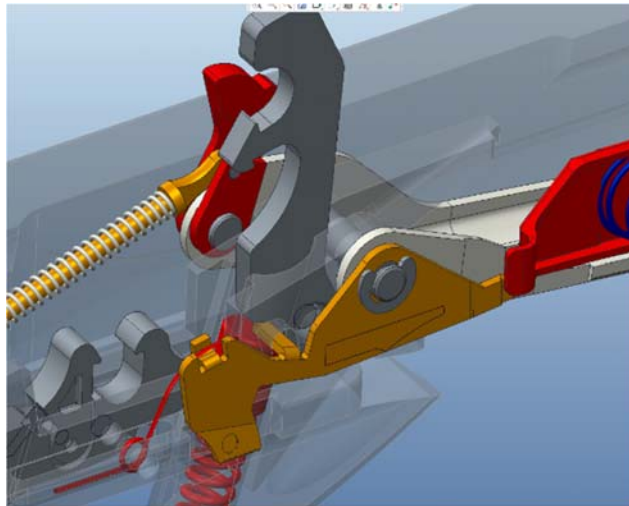


Figure 12. Parts of the movement.

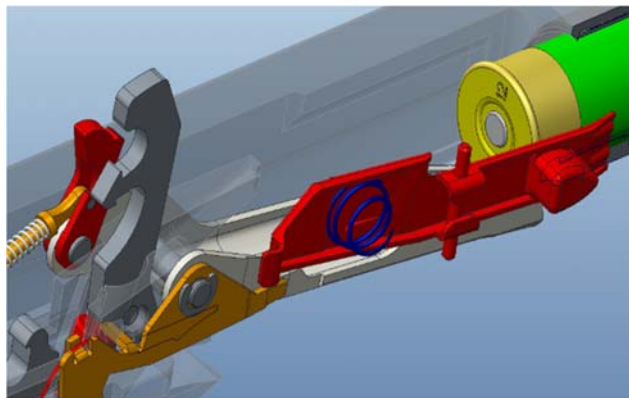


Figure 13. The opening of the flares road.

Just because of this, it should be tested with more people and to test different shoulder force on to the shotgun. The solution of this problem is to use a bolt

which is bearing diameter from upper receiver made of AISI4140. The most of the inertia driven system has a bearing system in the less surface resistance

aluminum channel to increase cocking energy. Hardness of 45-48 HRC on upper receiver provide longer duration of material and inside diameter mechanism bearing gain the less surface roughness (RA) and less friction to prevent operating problems [6].

Another factor in hunting rifles is the feeding system. The feed system allows the semi-automatic hunting rifle to refill and return the system to the shooting position by ejecting the empty shell from the ejection port. Feeding is the process of feeding a round into the chamber from the magazine which is located at bottom of the barrel. There are many pieces in the hunting rifles for this process

At the time of the rifle firing, the carrier holder and the feeding sheet are positioned as shown in the Figure 9 to block the cartridge in the magazine.

The carrier rotates with the releasing of the holder and opens the cartridge path. Finally, the mechanism is actuated by pushing of mechanism shut-off spring and cocking part on the top of the carrier raises the carrier

and feed the new cartridge which falls on the carrier, then the feeding operation is completed.

The closing pipe and the closing shaft which are another factors for the refilling force were also carried out. Al 7075 Aluminum is used to prevent surface deformations that experienced in Al 6061 Aluminum materials, radiuses and polishing operations are added to the steel closing shaft to reduce friction. Product of steel pipe that's made of 130HB was take strength to steel guide. The required inner surface roughness for the working of the design is provided by drawing method. From the movable parts of the shotgun, the CK60 sheet carrier has been getting loose during the firing with the ergonomic form of riveting method connection, as is the case with most rifles, and then it changed to the spot welding method. Although catching the position tolerances is difficult in the spot welding method, metering is provided and stronger joining is provided. Due to the unsuitable dimensional design to the machining, the precision casted button is manufactured from the same material (C60) as the carrier retaining plate so that it can be joined by the welding method.



Figure 14. Performing tests.

After the step of design, prototype has been produced. Prototype shotguns have been controlled with variety of tests. Some of the tests are mentioned below:

- Material Dimension Test: Space of Locking, Chamber and inside of barrel dimension are controlled.
- Validation Check: Shotguns are tested with high pressure shot shells.

- Shot penetration and Accuracy Test: Shot quantity counted and controlled on target.
- Hot and Cold Test: Shotguns are hold at -45 C and +55 C than shooting test applied.

After the tests are finished all parts are observed. Some of parts have been changed and the design of shotgun is completed.



Figure 15. Prototype rifle parts.

### 5. Conclusions

In this study, we aimed to design and produce sporting and hunting shotgun. Our goal is to find out the problem of current inertia driven shotguns and to apply radical changes on shotgun to minimize faults. Furthermore, we intended to produce user friendly, ergonomic, long-lived and high performance shotgun.

Feasibility studies, manufacturing and heat treatment methods, material types, materials and coating types are emphasized in designing.

In the shotguns the parts that located in the rear part of the barrel where the explosion occurs especially the chamber, the trigger group and the locking mechanism are exposed to the greatest strain. The materials used in the production of these parts must be able to

withstand the high number of shots. For this reason, the use of steel materials with high mechanical properties should be preferred in the production of these parts.

The minimum cost and maximum functionality are also taken into account when considering the commercialization stage of the product. Function, broad spectrum, life test, hot&cold shot, up and down shot, falling and accuracy tests were made and problems seen and the general series of manufacturing methods of gun-free shotgun were decided. Preliminary series production has been completed by commercialization which is one of the aims of the completed workshop.

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