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A STUDY AND EVALUATIONOF SYMMETRIC BULLET SHAPE MANUFACTURING PROCESS AT ELSHAJARA INDUSTRIAL COMPLEX

Hassan Abbas Hassan
PHD Student Professor
Faculty of post graduates
Nile Valley University, Atbara, Sudan

Mohamed M.I. Shukri
Professor
Faculty of Mechanical Engineering
Nile Valley University, Atbara, Sudan

Abstract: **The objective of this study is to optimizethe solution to the case of the Elshajara industrial complex (EIC) related to the symmetry of the bullets and dies. The plan was to investigate and identify the causes of the problem for this case study, looking for the optimal solution according to the available capabilities. In this research problem, its affect on aiming accuracy on the target of the bullet was studied through conducting investigations, analysis and evaluation, and then detecting the reasons that formed and solving them through the optimal solution that was made using the process of manufacturing for the local cutting tool and local dies, with capabilities available.**

The result of comparison of the required design shows great conformance between the quality control department test of the bullet photo manufactured by the imported dies, with the bullet photo manufactured by locally manufactured dies using the available capabilities.

Analysis of results has been presented and showed the advantages of remanufacturing of local cutting tool and local dies by using available capabilities.The research suggested somerecommendations to improve productivity, obtain quality and reliability.

***Keywords*— Bullet, accuracy, investigations, remanufacturing local cutting tool & local dies, inspections & tests, Fire tests.**

I. INTRODUCTION :

The bullet symmetrical shape manufacturing plays an important role in the quality and, the accuracy of aiming the target. Any asymmetry in the bullet is largely canceled as it spins. However, a spin rate greater than the optimum value adds more trouble than good, and Spin-stabilization is applied to the bullet upon launch to prevent it from falling out in flight, and this leads to inaccuracies.

Elashajara Industrial Complex was established for the production of small arms (lightweight) ammunition, including various types of bullets. The ammunition factory is facing a case for the manufacture of a 7.62x39 mm bullet from the Kalashnikov assault rifle in terms of quality and accuracy, especially in the advantage of aiming at the target. The problem may be from the dies or the bullet manufacturing process. This research studies and evaluates the manufacturing process of symmetric bullet shape and production conditions in the factory in order to find the optimal solutions to solve and improve this situation. Required work including study, inspection and production of local tools to make bullet dies and measure the quality and accuracy of products.

II. CARTRIDGE:

A cartridge is part of a round, which is a type of pre-assembled firearm ammunition packaging a projectile (bullet), a propellant substance (usually either smokeless powder or black powder) which is contained inside the cartridge and an ignition device (primer) within a metallic, paper or plastic case that is precisely made to fit within the barrel chamber of a breech loading gun, for the practical purpose of convenient transportation and handling during shooting.[1]

Figure (1) shows the 7.62X39 mm cartridge - FMJ (Full metal jacket).

Fig (1) 7.62×39 mm FMJ cartridge.

Components of a cartridge:[1]

Each of these cartridges consist of the following:
1. **bullet**, as the projectile : this is part of the cartridge that hits the target .
2. **cartridge case**, which holds all parts together.
3. **propellant**, for example gunpowder or cordite.
4. **rim**, which provides the extractor on the firearm a place to grip the casing to remove it from the chamber once fired.
5. **primer**, which ignites the propellant.

Figure (2) shows the cartridge components .

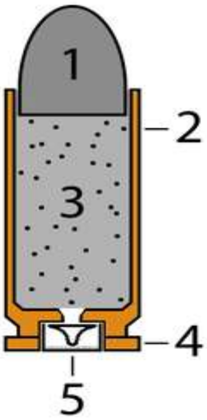

Fig (2) cartridge components [1]

Bullet:

A bullet is a kinetic projectile and the component of firearm ammunition that is expelled from the gun barrel during shooting. [2]
The term is from Middle French and originated as the diminutive of the word boulle (boullet), which means "small ball".[2]
Early projectiles (bullets) were made of stone, then iron, and later of the more densemetals such as lead. Lead bullets were at first spherical and loaded through the muzzle of unrifled smoothbore weapons.[3]
Today, bullets are made of a variety of materials such as copper, lead, steel, polymer, rubber and even wax, but lead is the traditional material of choice because of its high density, malleability, ductility and low cost of production. However, at speeds of greater than 300 m/s (980 ft/s), pure lead will deposit fouling in rifled bores at an ever-increasing rate. Alloying the lead with a small percentage of tin and/or antimony can reduce such fouling, but grows less effective as velocities are increased. A modern solution is to cover bare lead in a protective powder coat, as seen in some rimfire ammunitions. Another solution is to encase a lead core within a thin exterior layer of harder metal (e.g. gilding metal, cupronickel, copper alloys or steel), known as a jacketing.[1]

Bullets are made in various shapes and constructions depending on the intended applications, including specialized functions such as hunting, target shooting, training and combat.[2]

III. 7.62 X 39 MM AMMUITION:

Design features and ballistic properties:[4]

The M43(type of 7.62x39 mm ammunition) round is considerably less powerful that the standard battle cartridges of World War II. It is a cartridge of intermediate size- and power more powerful than the 30 M1 Carbine cartridge but less powerful than the .30–30 Winchester cartridge developed near the end of the 19th Century. The standard bullet weight for the M43 cartridge was slightly less than 8 grams (122 gr). Muzzle velocities for this bullet fired from SKS carbines and AK47 assault rifles are typically 2300 f/s to 2400 f/s (~720 m/s). Although described as 30 caliber bullets, they typically measure .310 in to .311 in (7.87mm–7.90mm) in diameter rather than .308 inches. This is in keeping with groove diameters of Soviet 7.62 mm rifles. The overall length of the M43 bullet is about 1.045 in (26.5 mm). The center of gravity for the M43 Soviet ball round is about 9mm forward of its base. The G1 ballistic coefficient (G1 BC) for this bullet is approximately 0.30.
In accordance with the military practices of virtually all countries in the 1940s and thereafter, the Soviet M43 bullet was of full metal jacketed design and possessed a spitzer point (sharply pointed bullet) figure (3) .

Fig (3) 7.62x39 mm- FMJ-BT bullet type[4]

Types of 7.62 x 39 mm ammunition:[5]
1-M43 :

The original Soviet M43 bullets are 123 grain boat-tail bullets with a copper-plated steel jacket, a large steel core, and some lead between the core and the jacket figure (4). The cartridge itself consisted of a Berdan-primed, highly tapered (usually steel) case which seats the bullet and contains the powder charge.

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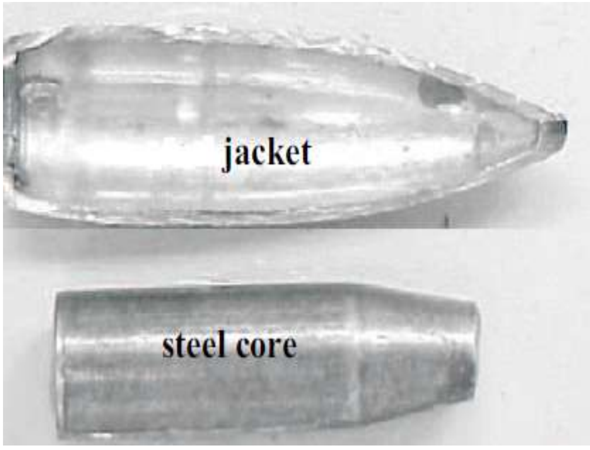

Figure (4) steel core of M43 bullet [4]

2-M67:

In the 1960s Yugoslavia experimented with new bullet designs to produce a round with a superior wounding profile, speed, and accuracy to the M43. The M67 projectile is shorter and flatter-based than the M43.

3-Commercial ammunition:

Commercial Russian-made 7.62×39mm ammunition, such as those sold under the Wolf Ammunition brand name, are also available in full metal jacket (FMJ), soft-point (SP) and hollow-point (HP) variety. The SP bullets offer improved expansion.

4-Type 56: Chinese Mild Steel Core:

Chinese (Type 56) military ammunition (developed in 1956) is a M43 style cartridge with a mild steel core (MSC) and a thin copper or brass jacket. In 1956, the Chinese developed their own 7.62x39mm assault rifle, also designated Type 56. It is a variant of the Soviet-designed AK-47 (specifically Type 3 and AKM) assault rifles.

Cartridge dimensions:[5]

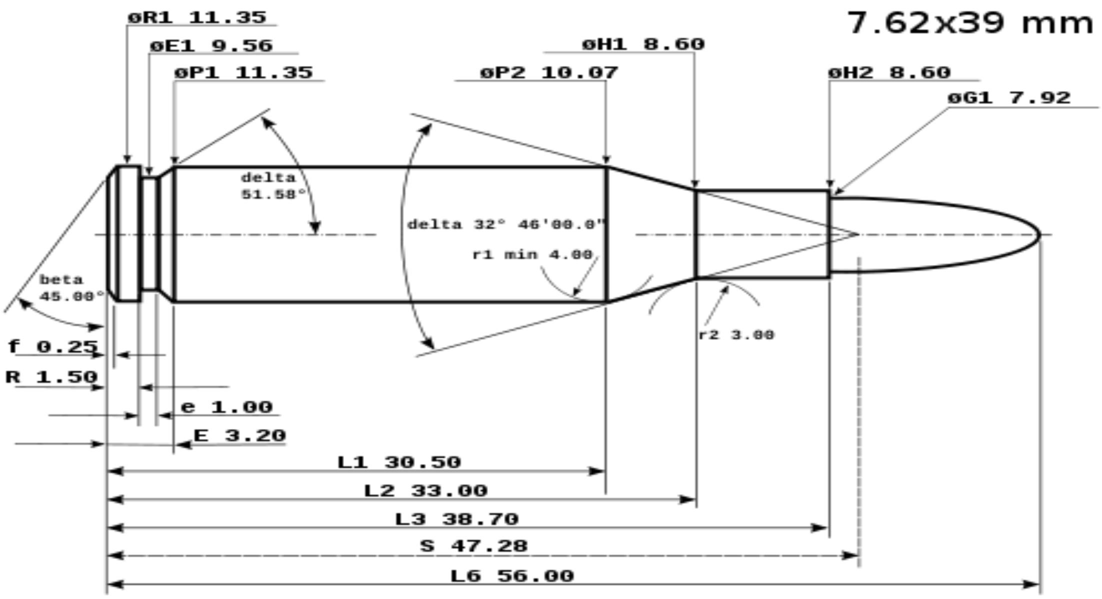

Fig (5) shows7.62×39mm maximum C.I.P. cartridge dimensions. All sizes in millimeters (mm).

Table (1) shows the basic specifications for several variants of 7.62×39mm:

Cartridge designation	**57-N-231**	**57-N-231P (tracer)**	**57-T-231PM1 (tracer)**
Cartridge weight	16.3 g (252 gr)	16.1 g (248 gr)	16.05 g (248 gr)
Bullet weight	7.9 g (121.9 gr)	7.57 g (116.8 gr)	7.55 g (116.5 gr)

Muzzle velocity	718 m/s (2,356 ft/s)	718 m/s (2,356 ft/s)	718 m/s (2,356 ft/s)
Muzzle energy	2,036 J (1,502 ft.lbf)	1,951 J (1,439 ft.lbf)	1,946 J (1,435 ft·lbf)
Accuracy of fire at 300 m (328 yd) R	75 mm (3.0 in)	140 mm (5.5 in)	140 mm (5.5 in)

R at 300 m (328 yd) means the closest 50 percent of the shot group will all be within a circle of the mentioned diameter at 300 m (328 yd).
Military 7.62×39mm ammunition is purportedly tested to function well in temperatures ranging from −50 to 50 °C (−58 to 122 °F) cementing its usefulness in cold polar or hot desert conditions.

Hunting and sport use:[5]

Since approximately 1990, the 7.62×39mm cartridge has seen some use in hunting arms in the U.S. for hunting game up to the size of whitetail deer, as it is somewhat less powerful than the .30-30 Winchester round, and has a similar ballistic profile. Large numbers of imported semiautomatic rifles, such as the SKS and AK-47 clones and variants, are available in this caliber. The lower cost and high availability of military surplus ammunition makes this cartridge attractive for many civilian hunters, plinkers, target and metallic silhouette shooters.

Features of 7.62x39 mm cartridge :
***Within its military role, the 7.62x39 mm cartridge and AK-47 rifle can be :**[6]
- Used to create effective suppressive.
- Offensive fire, only the ability to incapacitate.
- It is respected and famous around the globe.
-7.62x39 mm bullet is one of the most ballistically stable rifle bullets in existence and as a consequence, it often produces entrance and exit wounds in gunshot victims that look more like wounds from full metal jacketed pistol bullets than so-called high velocity wounds.
- Low cost.
- Extremely robust and reliable under adverse conditions.
- Modest recoil and generally acceptable accuracy made them very popular with recreational shooters.

***As a general hunting cartridge, the 7.62x39mm is** :[6]
- Best utilized at close ranges,
- Employing select shot placement.
- Adequate for shooting lighter framed game.
-Accurately controlled fire.
-Suitable ammunition and realistic expectations are the keys to success.

IV. ACCURACY:

The **accuracy** of a measurement is determined by how close a measured value is to its “true” value.
ISO defines **accuracy** as describing a combination of both types of observational error above (random and systematic), so high accuracy requires both high precision and high trueness. [7]
Accuracy is the proximity of measurement results to the true value.
Precision is the degree to which repeated (or reproducible) measurements under unchanged conditions show the same results Figure (6) and Figure (7) show that. [7]

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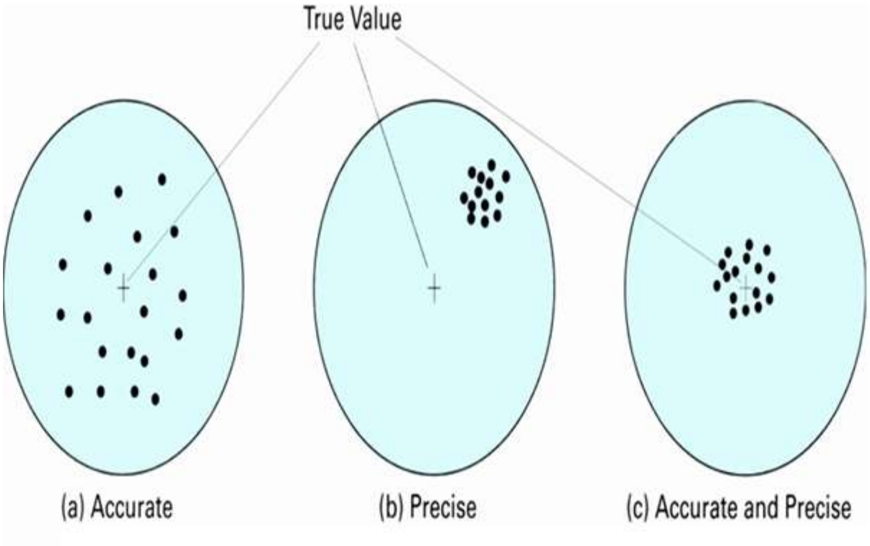

Fig (6) Difference between accuracy and precision . [8]

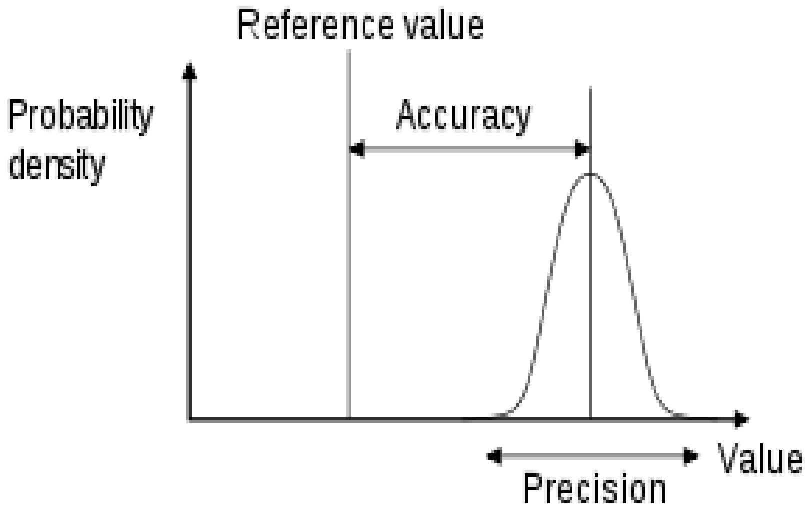

Fig (7) accuracy and precision

In the fields of science and engineering, the accuracy of a measurement system is the degree of closeness of measurements of a quantity to that quantity's true value. The precision of a measurement system, related to reproducibility and repeatability, is the degree to which repeated measurements under unchanged conditions show the same results.[7]

In military terms, accuracy refers primarily to the accuracy of fire, the precision of fire expressed by the closeness of a grouping of shots at and around the centre of the target figure (8) shows grouping of shots . In industrial instrumentation, accuracy is the measurement tolerance, or transmission of the instrument and defines the limits of the errors made when the instrument is used in normal operating conditions.[7]

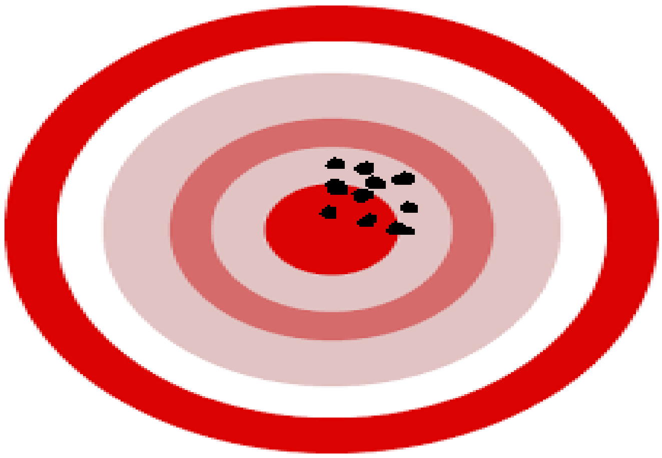

Fig (8) shows grouping of shots

Factors affecting accuracy:[9]
The accuracy of a shot relies on many different factors, which can be broken down into three broad categories: the firearm figure (9), the shooter and the cartridge.

1-The firearm factors are:

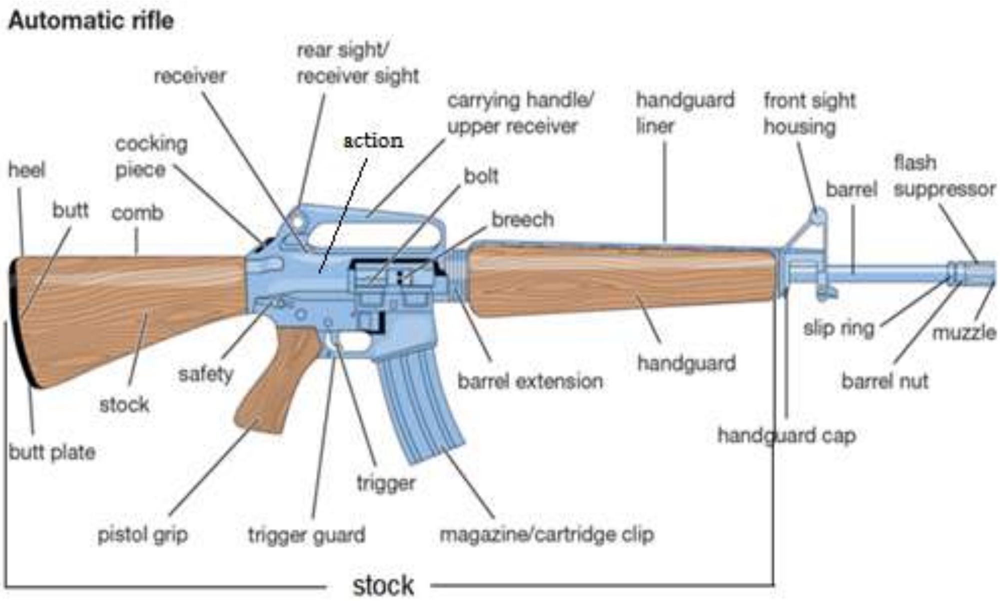

Fig (9) automatic rifle components

-Testing methodology:
- Usability:
-Sights:
-Barrel:
- Chamber:
-Rifle stocks**:**
-Clearances and Tolerances:

2- The shooter factors are:
-The ability of the shooter**.** [10]
-The precision and durability of the sights are very important. [10]
-The comfort, cool and stability of the firing position was the variable most strongly associated with the probability of best accuracy. [9]
-Having your finger on the trigger before the actual moment of shooting is dangerous and may loss accuracy. [10]
- Patience: The shooter needs to be patient and take as much time as needed when making each shot.
-Stocks and grips :

- Gripping surfaces**:**
-Time considerations:

3-The cartridge factors are:
- Harmonic geometric shape as a spherical shape was optimum to best accuracy.
- Symmetric shape of bullet: Any asymmetryin the bullet is largely canceled as it spins and loss accuracy.
- Bullets should be produced to a high standard from size and dimensions.
- Surface imperfections can affect firing accuracy.
- Bullet weight.

The symmetric shape of bullet & effects:

Symmetry of the bullet means that bullet should be identical along every direction from an imaginary line drawn from the center of the tip to the center of the base.[6]
Maximize part symmetry if possible or make parts obviously asymmetrical, it is important characterize from Boothroyd/Dewhurst Design Rules for assembly geometric shapes .[11]

V. THE FACTORS THAT AFFECTING FOR THE ACCURACY OF AIMING THE TARGET IN FIRING, SHOWN AS:

-Support spin-stabilization that applied to the bullet at launch to prevent its tumbling in flight.[12]
- Perfectly manufactured of symmetric shape effect in static and dynamic balance, profile shape, and axial symmetry.[12]
- Improve air flow and stability in flight. [13]
-The brass outer shell of symmetric of bullets engages the rifling tightly upon firing, providing a close fit for improved accuracy.[13]
- FMJ bullets, this helps maintains a bullet's shape in cycling and feeding as well as after firing, maintaining ballistic integrity throughout the process and accuracy to the target.[13]

VI.THE REQUIRED INVESTIGATIONS TO STUDY AND EVALUATION OF SYMMETRIC BULLET SHAPE THAT MANUFACTUREDAT EIC SHOWN AS:

1. The test of the bullet symmetrical shape for a random sample produced by the imported dies.
2. Investigation of shell thickness.
3. Investigation of shell filling.
4. Investigation of the shell cartridge casing.
5. Study of the dies (the internal cavity shape).
.The test of internal cavity shape for imported dies and local dies, before using by using lead material samples.
. The test of internal cavity shape for imported dies and local dies, after using by using wax material samples.
6. Investigation and follow up the manufacturing processes that related to bullets.
.All investigations were tested andevaluated using projector photos of the empty bullet figure(10). In addition to using all available local aids and capabilities.
All inspections were based on random sampling procedures of quality control.

Fig (10) Projector photo device.

VII. THE METHOD THAT SOLVED THIS PROBLEM:

Through the investigations that were conducted on the various tests on the empty bullet in terms of shape (symmetrical shape), thickness and dimensions and comparing them with the required design, we found varying differences.
It directly affected the shape of the bullet, which was coordinated and precisely regular, which depends mainly on the regularity of the internal shape of the die (symmetrical shape) and to the profile of the bullet targeted to be produced, which had an impact on not achieving the required accuracy in the fire tests, in addition to other affecting factors such as the weight of the bullet and others.
To solve this case, work has startedon the local production of empty bullet manufacturing dies with the available capabilities according to the following considerations:
-Manufacture of the local die by making tools locally, including local cutting tool, named counterbore (cutting tool forms the bullet profile shape in the inner cavity of the die), according to the specifications of the required bullet design.
-Efficiently working on the manufacture of local dies with excellent accuracy using the existing lathe machine.
-Work on making measurement gauges to ensure:
*Standard dimensions of the local dies and bullets and their extent to conformity with the required design.
*Depth inspection for the internal empty cavity for any local die.
*Inspection for the conformity of internal empty cavity shape to required design.
*Test of the symmetrical internal cavity shape of local dies.

*Finishing surfaces inspection for local dies before and after heat treatment.
-Work on the high finish of the local dies in terms of dimensions and the smoothness of the inner surface of the local die cavity according to the required design specifications.
- Giving the hardness of the local dies with the required accuracy according to the required design specifications.
- Performing all required tests to ensure the efficiency of the local dies in terms of operation and product quality.
-Inspections were conducted based on Random Sampling and inspect them on condition of conforming with required specification of bullet 7.62x39 mm such as inner diameter, outer diameter, length ,empty bullet weight and test of symmetric shape of bullet by using gauges and projector photo test .
-Finally Fire test:
Completed bullets are loaded into ammunition and fired to determine if they perform as expected and gaining the required results.

Flow chart for bullet 39x7.62mm & lead wire

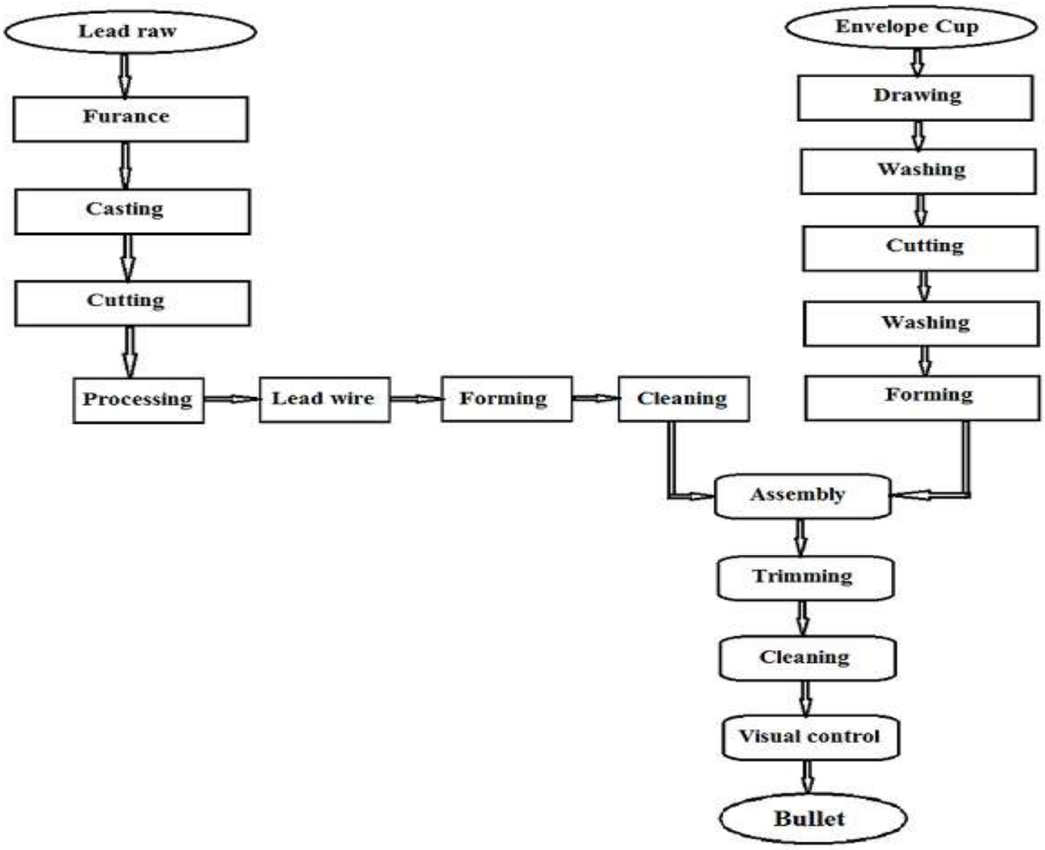

Fig (11) shows Flow chart for bullet 39x7.62 mm & lead wire.

VIII. METHOD OVERVIEW OF EIC CASE SOLUTION:

.An overview of the steps of studying and evaluating the symmetric bullet shape manufacturing process made at EIC is given as follows:
-Manufacture the local cutting tool called (counterbora) to manufacture the local dies.
-Manufacture of the local dies that produce the bullets.
-Verifying the usage of the gauges to measure the standard dimensions, the symmetric shape of the empty cavity of local dies and remanufacture the depth stick gauge ,the bullet profile shape gauges for inspection local dies and the bullet symmetrical shape gauge.
-Projector photos have been tested to verify that the finished bullets produced from local dies have passed all standardization standards tests and achieved conformance to the required design.
-All tests are carried out on the basis of random sampling and inspection provided that they conform to the required specifications of the 7.62x39 mm bullet such as the inner diameter, outer diameter, length, weight of the empty bullet, test the symmetrical shape of the bullet by using gauges and projector photos test. All inspections and testing were successful.

-Fire test with selected bullet groups (selected weights) achieved successful results for the required accuracy.

Comparison of the quality control department's test of imported dies with the test of local dies with the available capabilities:

-The test of quality control department for imported die:

Fig (12) shows the projector bullet photo produced by the imported dies for the quality control department.

-The test of projector bullet photo produced by local die :

Fig (13) shows the bullet projector photo of local dies.

When comparing the photos in figure (12) and figure (13), we have seen quite clearly the perfect fit between them.
This emphasizes that all local dies manufacturing processes have adhered to the maximum limits of conformity with the design required for the bullet product according to the available capabilities.

Fire test:

Fire test aims to achieve the success elements for any bullet to allow it to be used. These elements include reliability, accuracy and consistency performance. Reliability means every shot you fire will hit the target. [14]

The accuracy of all good cartridges is achieved through the careful combination of the components that make up them. [14]

The consistency performance is related to the flexibility and performance of the bullet in use. [14]

The fire test is also aimed at shooting accuracy expressed by the proximity of the group of shots in and around the center of the target. Figure (8) shows the grouping of shots.

The correct weight of the bullet has an essential and influential role in the fire test.

Through the fire test that worked for a number of bullet groups of differentweights together manufactured by local dies, it was found that:

These tests succeeded in achieving the goal of accuracy in three tests .

Achieving the best grouping area for the best result of fire test with determining the optimal weight range for that, figure (14) shown that.

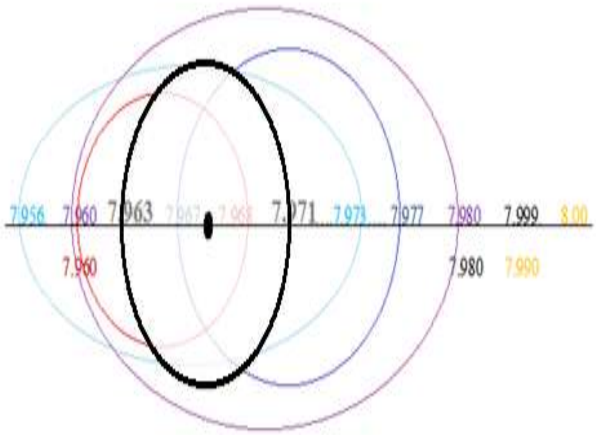

Fig (14) shows the closeness of a grouping of shots at and around the centre of the target with the optimal weight range.

IX RESULTS:

.The results of the study and evaluation of symmetric bullet shape manufacturing process at EICachieved some of the goals and requirements of EIC shown as:

i. Localization of manufacturing tools & dies.

ii. Minimizing the overall manufacturing cost.

iii. Verification of aiming the target of bullet product.
From all of the above, the goal of the EIC to aiming the target of bullet product and explained it with figures has been achieved, and that leads to some points:
•Determine the causes of the problem related to the case study by looking at the optimal solution according to the available capabilities.
• Supporting the local industry.
• Encouraging local employment and instilling confidence.
• Reducing the total cost to a minimum.
• Manufacture of products with international specifications and have global competitiveness.
•Increase the company profit.
•Satisfaction of the customers.

X. CONCLUSION:

This paper discussesed and analyzesed the local dies manufa cturing methodology.
The existing process of tools manufacturing is investigated and errors discovered, and new dies are being produced. Local dies have been put into production, and the results are satisfactory.

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