

# Mechanical Engineering in Ancient Egypt, Part 99: Spears, Shields, Daggers, Swords and Military Chariots Industry

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## Abstract:

This paper is one in a series of research papers aiming at investigating the role of ancient Egyptians in the development of Mechanical Engineering. It studies the production of some ancient weapons used by the Egyptian army during the Predynastic and Dynastic Periods. It presents the features of the spears, shields, daggers, swords and military chariots as ancient Egyptian weapons. 37 examples are presented and analyzed from mechanical point of view.

**Keywords** — Mechanical Engineering history, ancient Egyptian weapons, spears, shields, daggers, swords, military chariots industry.

## I. INTRODUCTION

The ancient Egyptians were pioneers in establishing wonderful well-organized industries including some military industries. The military industry was essential to protect the territories of Egypt from four directions: East, West, South and North. The present paper focuses on the industry of spears, shields, daggers and chariots.

Shaw (1991) in her book about Egyptian warfare and weapons studied the

Weapons and military technology in ancient Egypt. She presented the wooden model of soldiers carrying spears and shields from the tomb of Mesehty, typical spears from Old to New Kingdoms, chariot from the Second Intermediate Period, chariot relief for Pharaoh Seti I in the Karnak Temple and scene for chariot with two soldiers from the New Kingdom [1]. Spalenger (2003) in his paper about the Battle of Kadesh presented a relief for the Egyptian chariot during the Battle of Kadesh in different resources. He presented also reliefs for the enemy chariots during the same battle [2].

Olivier (2008) in her thesis of Master of Arts presented a scene for Pharaoh Akhenaten and his wife Nefertiti in their chariots with soldiers holding spears and shields [3]. Amar (2012) in her study of the dagger of Pharaoh Kamos from the 17<sup>th</sup> Dynasty

presented an explanation of the dagger parts supported by eight photos. She compared Kamos dagger with that of Queen Ahhotep from the End of the 17<sup>th</sup> Dynasty [4]. Sabbahy (2013) in her study of chariot use in the New Kingdom of Egypt presented some useful reliefs illustrating the use of chariots during the New Kingdom. Some of them are: relief for archer and shield bearer from the Great Temple at Abu Simbel, Prince in his chariot following Ramses II in one of his battles, Amenemhat II in his chariot, Thutmose IV in his chariot, Akhenaten stepping into his chariot and Ramses III in his chariot [5]. Dean (2013) in her book about women, weaponry and warfare presented a relief for Queen Nefertiti smiting a female prisoner with a Khopesh, a scene for Queen Tawosert fighting in a chariot, a relief for a military vehicle in the tomb of Horemheb, a relief for infantry soldiers carrying spears and shields in Luxor Temple, a fighting scene using military chariots from the Temple of Horemheb, the dagger of Queen Ahhotep, a relief for Queen Nefertiti driving her chariot, a scene for Queen Tawosert in a chariot during a battle, a scene for Thutmose IV in his chariot during a battle, a relief for Seti I in his chariot fighting the Hittites, a relief for Ramses III in his chariot with his infantry soldiers carrying spears and shields, a photo for a war chariot from the New Kingdom a relief for Ramses II fighting in his chariot, photos for swords

and dagger from the New Kingdom, a dagger from the Middle Kingdom, a straight sword from Early 18<sup>th</sup> Dynasty and photos for Khopesh swords [6].

Wernick (2015) in his paper about ancient Egyptian shields and their handles published a collection of wooden shield-handles and examined the shields found in the tomb of Tutankhamun and concluded that the design of the shield and handle placement and orientation changed [7]. Chondross et al (2016) in their paper about the evolution of the double-horse chariots presented some useful scenes for the use of chariots including scene for a Hittite chariot with two horses, a relief for two horses chariot from Late Hittite, a photo for Achaean chariot with L-shaped pole, a photo for a two horses Egyptian chariot produced 1500 BC, a relief for Ramses II in his chariot in Abu Simbel Temple, a scene for ancient Egyptian carpenters producing chariot wheels [8].

Comelli et al (2016) in their article about the meteoritic origin of Tutankhamun's dagger blade presented a photo for the iron dagger of Tutankhamun with its golden shield. They concluded that the ancient Egyptians attributed great value for meteoritic iron for the production of precision objects and the Tutankhamun's iron dagger blade had high manufacturing quality suggesting a significant mastery of ironworking in Tutankhamun's time [9]. El-Mahdy (2017) in her paper about some weapons of the Gods in ancient Egypt presented a colored scene for Genies deity holding knife in each hand as a weapon, scene for Horus holding a mace and shield, line diagram for different types of swords, a statue for Horus holding a Khopesh from the 26<sup>th</sup> Dynasty [10].

Wadi (2017) in her paper about Egyptian treatment of sword injuries presented a photo for a Khopesh produced in 1750 BC in ancient Egypt and a relief for Ramses II using the Khopesh [11]. Mazza et al (2018) studied the dynamics of an Egyptian and American war chariots using vehicle dynamics simulation software. The results revealed important information about the chariot stability, reliability and structural integrity. They concluded that the Egyptian chariot was technically much more advanced than the American [12]. White (2020) in his thesis about bows and spears in Achaemenid Persia presented a relief for an

Egyptian bow workshop and photo for the stele of the vultures from Dynasty III of Mesopotamia displaying a number of spears [13]. Wikipedia (2021) wrote an article about chariotry in ancient Egypt and displayed a relief for Ramses II fighting in his chariot during the Battle of Kadesh from Abu Simbel Temple. They outlined that Kamose (1555-1550 BC) was the first Egyptian ruler to use chariots in a battle, then followed by New Kingdom rulers [14]. Hassaan (2021) investigated the industry of maces, axes and bows and arrows as weapons used by the ancient Egyptian armies. He presented examples of using the three weapons and mentioned their characteristics and present location [15].

## **II. SPEARS INDUSTRY IN ANCIENT EGYPT**

The ancient Egyptians used spears as a personal weapon since the Predynastic Period and continued to use it down to the Late Period as will be depicted by the following examples:

- The first example is a flint spear-head from the Predynastic Period, 4400-3150 BC in display in the Brooklyn Museum at New York and shown in Fig.1 [16]. But why the ancient Egyptian designer used the flint rock as a raw material for this weapon produced about 6000 years ago?. Because they were genius, they knew that flint is harder than other metals such as copper and iron. Recent studies showed that the Egyptian flint has a hardness of 7 on Mohs scale [17] while copper has a hardness of 3 and ordinary steel has a hardness of 4.5 [18]. Therefore, flint was superior in providing resistance to decay and offered particular reliability [17]. This is besides its ability to be sharpened.



Fig.1 Flint spear-head from the Predynastic Period [16].

- The second example is a copper alloy spear head from Early 3<sup>rd</sup> Dynasty, 2686-2613 BC in display in the British Museum and shown in Fig.2 [19]. Most probably the spear head

material is a copper-tin alloy (ancient Egyptian bronze). The spear head design and material has the features:

- The shape of the head became much complex than the stone one.
- The front part has more than two sharpened edges to increase the killing efficiency of the weapon.
- The end of the head is thinned to suit the fixed connection with the spear hand.
- In this design, the designer used bitumen as an adhesive between the head and the hand [19].
- The mechanical designer used bronze as a raw material for this application since it has tensile strength of about twice that of copper [20].
- Selecting copper tin alloy (bronze) as a material for the spear head provides excellent cold and hot formability and good resistance to atmospheric corrosion [21].



Fig.2 Copper alloy spear head from the 3<sup>rd</sup> Dynasty [19].

- The third example is an electrum spear head from a Royal tomb from the Early 3<sup>rd</sup> Dynasty, 2600-2500 BC in display in the British Museum and shown in Fig.3 [22]. As this weapon is from a Royal tomb, most probably it was a ceremonial spear head. This is why the designer selected electrum as a raw material for this product to increase its historical value and life by selecting a precious metal. It has a tensile strength better than gold, silver and copper [23-24]. Its hardness is similar to that of gold and silver and its maximum harness is similar to copper hardness [25,26]. The surface roughness of the electrum spear head is much less than that of bronze head of Fig.2.



- The fourth example is a wooden model for a striding infantry troops found in the tomb of Mesehty, Governor of Asyut during the 11<sup>th</sup>

Dynasty of the Middle Kingdom, 2000 BC in display in the Egyptian Museum at Cairo and shown in Fig. 4 [27]. The model depicts the soldiers carrying long spears in their right hands.



Fig.4 Model of infantry troops from the 11<sup>th</sup> Dynasty [27].

- The fifth example is a colored relief of Nubian soldiers carrying spears and shields from the 12<sup>th</sup> Dynasty, 1955-1750 BC shown in Fig.5 [28]. The relief depicts the soldiers carrying long identical spears and blue hamlets. The activity was authorized using hieroglyphic text carved in rows above the soldier heads.



Fig.5 Relief of soldiers from the 12<sup>th</sup> Dynasty [28].

- The sixth example is a copper alloy spear head from the 18<sup>th</sup> Dynasty, 1550-1295 BC in display in the Petrie Museum at London and shown in Fig.6 [29]. The spear head has 240

mm overall length, ovoid blade and hollow sleeve to support the spear shaft. Most probably this unit was produced using metal casting where the ancient Egyptians were pioneers in this industry during this Period of their history [30].



Fig.6 Spear head from the 18<sup>th</sup> Dynasty [29].

- The seventh example is an iron spear head from the Late Period, 664-332 BC in display in the Petrie Museum at London and shown in Fig.7 [31]. The spear head was corroded due to the environmental effects associated with iron.



Fig.7 Iron spear head from the Late Period [31].

### III. SHIELDS INDUSTRY IN ANCIENT EGYPT

The ancient Egyptians used shields to protect fighters against arrows, spears and swords. They used various materials and designs to facilitate using shield effectively. Here are some examples:

- The first example is a wooden model for a striding infantry troops found in the tomb of Mesehty, Governor of Asyut during the 11<sup>th</sup> Dynasty of the Middle Kingdom, 2000 BC in display in the Egyptian Museum at Cairo and shown in Fig. 4 [27]. The model depicts the soldiers carrying shields in their left hands.
- The second example is a 715 x 422 mm wooden shield model from the 12<sup>th</sup> Dynasty, 1981-1802 BC in display in the Metropolitan Museum of Art at New York and shown in



Fig.8 Shield model from the 12<sup>th</sup> Dynasty [32].

- The third example is a colored relief for Nubian soldiers in the Egyptian army during the 12<sup>th</sup> Dynasty, 1955-1750 BC shown in Fig.5 [28]. The relief depicts the soldiers holding the shields by their left hands and depicts also its material as animal skins.
- The fourth example is a ceremonial shield for Tutankhamun, the 13<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1332-1323 BC shown in Fig.9 [34]. The shield was decorated by a 3D relief showing the Pharaoh as a sphinx wearing the combined crown of Egypt and squeezing the enemies of Egypt under his feet. The activity

was recorded using the hieroglyphic script with a text bounded by a frame.



Fig.9 Ceremonial shield from the 18<sup>th</sup> Dynasty [34].

#### IV. DAGGERS INDUSTRY IN ANCIENT EGYPT

The ancient Egyptians used daggers as a personal light weapon. Here are some examples about their design and characteristics as used by the ancient Egyptians:

- The first example is a dagger with golden blade from Early 3<sup>rd</sup> Dynasty of the Old Kingdom, 2600 BC in display in the British Museum at London and shown in Fig.10 [35]. The dagger has a straight blade and its hand was decorated by pieces of gold at its end (pommel). Besides, most probably the guard was also produced from gold. This means that this dagger may be a Royal ceremonial one.



Fig.10 Golden blade dagger from the 3<sup>rd</sup> Dynasty [35].

- The second example is a dagger from the Middle Kingdom 2025-1700 BC in display in the Petrie Museum at London and shown in Fig.11 [36]. The dagger has a straight blade, a

thin handle and a big crescent ivory pommel. Its edges have a parabolic shape.



Fig.11 Dagger from the Middle Kingdom [36].

- The third example is a wooden model dagger of Ukhhotep, Overseer of Priests of Hathor during the reign of Senusret I, 2<sup>nd</sup> King of the 12<sup>th</sup> Dynasty, 1971-1926 BC in display in the Metropolitan Museum of Art and shown in Fig.12 [37]. The dagger model has a straight blade, a thick handle and a pommel and guard of almost the same diameter.



Fig.12 Dagger model from the 12<sup>th</sup> Dynasty [37].

- The fourth example is a dagger from the 12<sup>th</sup> Dynasty, 1938-1759 BC in display in the Brooklyn Museum at New York and shown in Fig.13 [38]. The dagger has a straight copper alloy blade, straight guard, concave handle and ivory crescent pommel. The mechanical designer of the dagger selected two techniques to secure the pommel to the handle: ending the handle with a sleeve with interference fit with the pommel and forming an adhesive fit between the pommel and an extension part of the handle with less diameter than the handle diameter.



Fig.13 Dagger from the 12<sup>th</sup> Dynasty [38].

- The fifth example is a dagger of Princess Ita, daughter of Amenemhat II, 3<sup>rd</sup> King of the 12<sup>th</sup> Dynasty, 1929-1897 BC in display in the Egyptian Museum at Cairo and shown in Fig.14 [39]. The dagger may be considered as a master piece of the daggers industry during the Middle Kingdom. Its blade was produced from bronze, its guard was produced from gold, its hand and crescent pommel were inlaid by lapis lazuli and inlaid by gold and carnelian.



Fig.14 Bronze dagger from the 12<sup>th</sup> Dynasty [39].

- The sixth example is a 380 mm length dagger from the 18<sup>th</sup> Dynasty, 1550-1295 BC in display in the Metropolitan Museum of Art and shown in Fig.15 [40]. The dagger blade and handle are manufactured using bronze and the pommel had a semi-circular shape and produced from ivory with a special fixture with the handle.



Fig.15 Bronze dagger from the 18<sup>th</sup> Dynasty [40].

- The seventh example is a dagger of Queen Ahhotep, Mother of Ahmose I, Founder of the 18<sup>th</sup> Dynasty, 1549-1514 BC in display in the Egyptian Museum at Cairo and shown in Fig.16 [41,42]. The dagger blade is straight

and most probably produced from bronze. It has some distinct features:

- The guard and handle are integrated in one part with straight sleeve holding the blade and a crescent guide and fork holding the pommel. Probably, its material may be gold or electrum.
- The pommel is circular and produced from ivory as a disc secured in position by the crescent and fork parts of the handle-guard element.



Fig.16 Royal dagger from Early 18<sup>th</sup> Dynasty [41,42].

- The eighth example is a golden dagger of Tutankhamun, the 13<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1332-1323 BC in display in the Egyptian Museum at Cairo and shown in Fig.17 [43]. The details of the pommel, handle and guard are presented in Fig.18 [44]. The pommel has a parabolic shape and decorated by two Cartouches of the Pharaoh from one side and two figures for the falcon holding the shen symbol in his claws. The hand was decorated by a system of advanced motifs with elaborated techniques using geometrical shapes and lily palmetto produced using gold and semi-precious stones and glass in an alternate bands [45]. The guard is relatively thin and has little increased diameter than the end part of the handle.



Fig.17 Golden dagger from the 18<sup>th</sup> Dynasty [43].



Fig.18 Pommel, handle and guard of Tutankhamun golden dagger [44].

- The ninth example is an iron dagger of Pharaoh Tutankhamun of the 18<sup>th</sup> Dynasty in display in the Egyptian Museum at Cairo and shown in Fig.19 [46]. The pommel design is different than that of the golden dagger of Fig.18. Here, it is straight ending with a rounded disk. Probably it is produced from silver or glass. The handle geometry is different than that in Fig.18. Here, it has a parabolic shape while in Fig.18; it has a concave shape with almost same decorations. The guard here is also different where it is straight and thicker than in Fig.18.



Fig.19 Iron dagger from the 18<sup>th</sup> Dynasty [46].

## V. SWORDS INDUSTRY IN ANCIENT EGYPT

The ancient Egyptians used swords as early as the Middle Kingdom where it was an offensive sharp weapon. Here are some examples of swords used by the ancient Egyptians during the Middle and New Kingdoms:

- The first example is a Khopesh from the 13<sup>th</sup> Dynasty of the Middle Kingdom, 1750 BC in display in the Museum Agyptischer Kunst, Munchen and shown in Fig.20 [47]. Most probably this is a bronze Khopesh of the sickle shape with the sharpened cutting blade on the outer surface of its front part.



Fig.20 Khopesh from the 13<sup>th</sup> Dynasty [47].

- The second example is a 318 mm length Bronze sword from the New Kingdom, 1550-1069 BC in display in the British Museum and shown in Fig.21 [48]. The design of this sword presents relatively short straight sword. The pommel has a half circular shape, the grip consists of two parts separated by two sleeves, the guard is a thin disc with white inlay and the blade has a double convex shape forming an ovoid with inlay near the guard.



Fig.21 Bronze sword from the New Kingdom [48].

- The third example is a 520 mm length copper alloy sword from the Early 18<sup>th</sup> Dynasty, 1550-1458 BC in display in the Metropolitan Museum of Art at New York and shown in Fig.22 [49]. The design of this sword presents a medium straight sword. The pommel has a semi-spherical shape; the grip is straight and ending with a parabolic connection with the guard which is flat and thicker than that of the design in Fig.21. The blade has a slight concave surface and round tip. The unit is an indication of the development of the metal casting technology in ancient Egypt during this era.



Fig.22 Copper alloy sword from Early 18<sup>th</sup> Dynasty [49].

- The fourth example is a Khopesh for Akhenaten, the 10<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1351-1334 BC in display in the Metropolitan Museum of Art at New York and shown in Fig.22 [50]. Most probably this is a bronze Khopesh with a standard design for the Khopesh.



Fig.23 Khopesh of Akhenaten from 18<sup>th</sup> Dynasty [50].

- The fifth example is a 520 x 222 mm sandstone 'talatat' with Royal boats scenes from the reign of Pharaoh Akhenaten of the 18<sup>th</sup> Dynasty in display in the Museum of Fine Arts at Boston and shown in Fig.24 [51]. The scene depicts a man adjusting the sail of a Royal boat, while two men are holding a Khopesh in their right hands.



Fig.24 Talatat scene from 18<sup>th</sup> Dynasty [51].

- The sixth example is a bronze Khopesh of Pharaoh Tutankhamun of the 18<sup>th</sup> Dynasty in display in the Egyptian Museum at Cairo and shown in Fig.25 [52]. The blade is curved at its end taking a sickle, the grip is straight and decorated by inlays, the guard is small and the

pommel is oriented towards one direction only.



Fig.25 Khopesh of Tutankhamun from the 18<sup>th</sup> Dynasty [52].

- The seventh example is a sword blade from the 19<sup>th</sup> Dynasty, 1292-1186 BC in display in the National Museum of Scotland at Cairo and shown in Fig.26 [53]. It is straight and probably made of bronze with compound blade-profile (concave near the tip followed by convex near the guard. There is a fuller all over its length.



Fig.26 Sword blade from the 19<sup>th</sup> Dynasty [53].

- The eighth example is a relief for Seti I, the 2<sup>nd</sup> Pharaoh of the 19<sup>th</sup> Dynasty, 1290-1279 BC in the northern exterior wall of the Karnak Hypostyle Hall shown in Fig.27 [54]. The relief depicts the Pharaoh fighting the Libyan enemies of Egypt using a Khopesh. The Pharaoh is riding a military vehicle.



Fig.27 Seti I fighting with a Khopesh from the 19<sup>th</sup> Dynasty [54].

- The ninth example is a bronze Khopesh for Ramses II, the 3<sup>rd</sup> Pharaoh of the 19<sup>th</sup> Dynasty, 1279-1213 BC in display in the Louvre Museum at Paris and shown in Fig.28 [55,56]. It has the standard Khopesh design appeared in the New Kingdom.





Fig.28 Ramses II Khopesh from the 19<sup>th</sup> Dynasty [55].

## VI. MILITARY CHARIOTS INDUSTRY IN ANCIENT EGYPT

The ancient Egyptians new the military chariots through the direct contact with Hyksos during their occupation of Lower and Middle Egypt during the period 1650-1550 BC [57]. The ancient Egyptians became superior in constructing military chariots as will be depicted by the following examples:

- The first example is a jasper scarab with a relief for Thutmose I, the 3<sup>rd</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1503-1493 BC in display in the British Museum and shown in Fig.29 [58]. The carved scene on the jasper scarab depicts the Pharaoh on his military chariot attacking an enemy soldier using his bow and arrows weapon. The scene authorizes the documentation of the activity through carving the Cartouche of the Pharaoh in the top middle of the scene.



- The second example is a relief for Amenhotep II, the 7<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1475-1398 BC in the Karnak Temple and shown in Fig.30 [59]. The relief depicts the Pharaoh in his war chariot and putting three of his captives on the driving horse. The chariot of Pharaoh Amenhotep II was driven by a single

horse and the wheels of his chariot had four spokes.

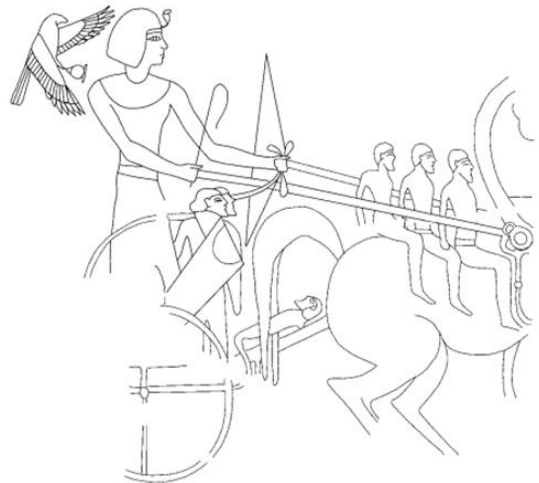


Fig.30 Karnak relief from the 18<sup>th</sup> Dynasty [59].

- The third example is a relief for Amenhotep II of the 18<sup>th</sup> Dynasty, 1475-1398 BC in a stela from the Temple of Amun at Karnak shown in Fig.31 [60]. The relief depicts the Pharaoh in his chariot driven by two horses and shown shooting arrows against targets. The wheels of his chariot had four spokes.



Fig.31 Stela relief from the 18<sup>th</sup> Dynasty [60].

- The fourth example is a chariot scene in the tomb of Nebamun, Scribe and Grain Accountant during the reign of Pharaoh Thutmose IV of the 18<sup>th</sup> Dynasty, 1392-1350 BC in display in the British Museum and shown in Fig.32 [61]. The scene depicts Nebamun checking up his single-horse-driven chariot. The wheels of his chariot had six spokes.



Fig.32 Chariot scene from the 18<sup>th</sup> Dynasty [61].

- The fifth example is a scene in the tomb of Pharaoh Thutmose IV of the 18<sup>th</sup> Dynasty, 1398-1388 BC shown in Fig.33 [62]. The scene depicts the Pharaoh fighting Asiatic enemies of ancient Egypt using his two-horse military chariot. The wheels of his chariot were modified to have eight spokes for more strength. The scene depicts also the military vehicles of the enemies driven by two horses and having only four spokes.

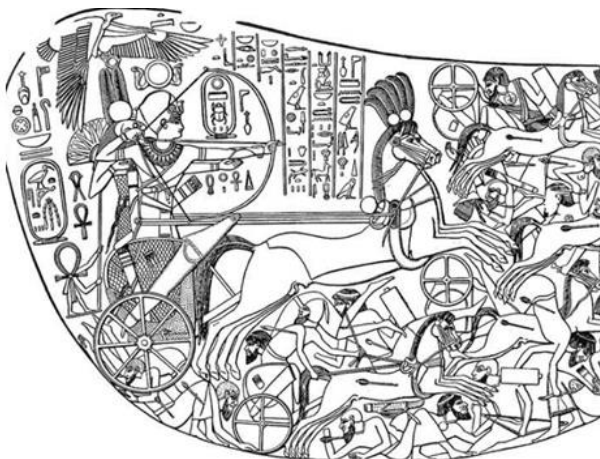


Fig.33 Tomb war scene from the 18<sup>th</sup> Dynasty [62].

- The sixth example is a scene in the chapel of the priest Merya at Amarna shows the Pharaoh Akhenaten and his Queen travelling in separate chariots. Akhenaten was the 10<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1351-1334 BC and the scene is shown in Fig.34 [63]. The scene depicts Royal chariots driven by two horses with two wheels having six spokes each.



Fig.34 Scene for Akhenatin and his wife from the 18<sup>th</sup> Dynasty [63].

- The seventh example is a colored scene for Tutankhamun, the 13<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty, 1332-1323 BC on a side of one of his chests in display in the Egyptian Museum at Cairo and shown in Fig.35 [64]. The scene depicts the Young Pharaoh in his military chariot fighting the Africans. The scene depicts a chariot driven by two horses with two wheels having six spokes each. The Vehicle Corps Forces of the Pharaoh were shown using chariots of the same design as that of the Pharaoh.



Fig.35 Scene for Tutankhamun from the 18<sup>th</sup> Dynasty [64].

- The eighth example is a colored scene for Pharaoh Ramses II of the 19<sup>th</sup> Dynasty, 1279-1213 BC in his chariot fighting in one of his battles drawn on a pottery fragment as shown in Fig.36 [65]. The ancient Egyptian artist could register this wonderful colored scene for his great Pharaoh with details of the chariot and driving horses. Not only this, but he authorized the Pharaoh's battle using the hieroglyphic script with text written within seven bounded columns.



Fig.36 Scene for Ramses II from the 19<sup>th</sup> Dynasty [65].

- The ninth example is a scene for Tausret, the 8<sup>th</sup> and last Pharaoh of the 19<sup>th</sup> Dynasty, 1191-1189 BC in her military chariot fighting with a bow and arrows as painted on an ostrakon in display in the Egyptian Museum at Cairo and shown in Fig.37 [66]. The scene depicts her military chariot driven by a single horse and a horse-driver with chariot-wheels having eight spokes.



Fig.37 Scene Tausret from the 19<sup>th</sup> Dynasty [66].

## VII. CONCLUSION

- The development of Mechanical Engineering in ancient Egypt was studied through investigating the industry of some weapons in ancient Egypt.
- The study covered spears industry during a time span from the Predynastic to the Late Periods.
- The study covered shields industry during a time span from the 11<sup>th</sup> to the 18<sup>th</sup> Dynasties.
- The study covered daggers industry during a time span from the 3<sup>rd</sup> to the 18<sup>th</sup> Dynasties.

- The study covered swords industry during a time span from the 13<sup>th</sup> to the 19<sup>th</sup> Dynasties.
- The study covered military chariots industry during a time span from the 18<sup>th</sup> to the 19<sup>th</sup> Dynasties.
- The ancient Egyptians authorized the spears industry through full-scale spear heads, wooden models of infantry troops equipped with spears and tomb reliefs.
- The ancient Egyptians authorized the shields industry through wooden models, tomb reliefs and ceremonial units.
- The ancient Egyptians authorized the daggers industry through wooden models and full-scale daggers.
- The ancient Egyptians authorized the swords industry through full-scale swords, colored scenes and temple reliefs.
- The ancient Egyptians authorized the military chariots industry through carving on small units such as scarabs, drawing scenes on furniture units such as chests, scenes on pottery fragments, scenes on ostracons and full-scale swords.
- They used different designs for the dagger-pommel, hand and guard
- They used ivory and semi-precious stones for the decoration of the dagger-pommels and hands.
- They produced daggers using gold, bronze and iron materials.
- They designed swords with straight blade or curved blade (the Khopesh).
- They used copper-alloy and bronze as production materials.
- They used various designs for the sword pommel, grip and guard.
- They designed military chariots driven by one or two horses.
- They designed military chariots with various strength characteristics through the number of spokes in each wheel.
- They designed and produced chariot wheels with:
  - Four spokes (during the 18<sup>th</sup> Dynasty).
  - Six spokes (during the 18<sup>th</sup> and 19<sup>th</sup> Dynasties).

- Eight spokes (during the 18<sup>th</sup> and 19<sup>th</sup> Dynasties).
- Male and female Pharaohs of ancient Egypt participated in fighting Egypt's enemies by themselves leading their armies using axes, swords, bow and arrows and military chariots.

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