

Mechanical Engineering in Ancient Egypt, Part 57: Footwear Industry

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Abstract:

This paper is the 57th research paper in a series investigating the evolution of mechanical engineering in ancient Egypt. It tries to achieve this purpose through investigating the footwear industry through the Dynastic Periods. It outlines the footwear designs and production techniques used by the ancient Egyptians. Types of footwear are covered with extensive examples from different eras highlighting the characteristics of each footwear. Used materials are assigned (if available) to complete the design requirements in any age including the present days.

Keywords — Mechanical engineering; ancient Egypt; footwear industry, sandals, shoes.

I. INTRODUCTION

This is the 57 paper in a series of research papers aiming at exploring the role of ancient Egyptians in the evolution of mechanical engineering. The paper focuses on the footwear industry in ancient Egypt during the Dynastic Periods from Early Dynastic to Late Period.

Veldmeijer (2009) described and discussed the manufacturing technology of a pair of leather shoes in the Egyptian Museum at Cairo. He presented a detailed comparison with previously described footwear showing a close relationship with other composition sandals [1]. Veldmeijer (2009) presented a category of fibre sandals called 'coiled sewn sandals'. He focused on technologies and aspects including description. He defined the 'sewing' process as a technique in which a horizontal bundle of material is fastened to another bundle by wrapping with a strip of vegetable material. He presented sample sandals from the Egyptian Museum at Berlin and Petrie Museum at London [2].

Veldmeijer (2009) focussed on the technological aspects of a pair of leather open shoes in the Department of Ancient Egypt and Sudan at the British Museum. He presented a description for the 230 mm length leather open shoes and his

opinion about the manufacturing methods used in its production. He outlined Petrie opinion that leather variant occurred during the Middle Kingdom [3]. El-Hadidi and Hamdi (2011) studied the materials and technologies of two sandals and two shoes at the Agricultural Museum in Giza from the New Kingdom. They outlined that the soles of the sandals were produced using either a plaiting or sewing techniques [4]. Veldmeijer (2014) presented the footwear collections housed in the Medelhavsmuseet in Stockholm. He presented leather open shoes of Tutankhamun, sandals of Tutankhamun and closed shoes from the New Kingdom. He presented a short survey of footwear through time from Predynastic to Roman Periods [5].

Mohammed et. Al. (2015) studied one pair sandals of the 32 pair footwear of Pharaoh Tutankhamun. They investigated the type of fibres used in the sandals, assessment of the cell wall of the fibres and imaging with SEM. They made a model replicate facilitate reconstruction of the sandal [6]. En Chronicles (2016) wrote an article about footwear in ancient Egypt. They outlined that ancient Egyptians used different materials in making sandals and shoes including fibre, strew, leather and wood. They presented wooden , open shoes, leather shoes, fibre sandals, Tutankhamen's statue wearing a sandal, Tutankhamen's golden

sandal, colored shoes of Tutankhamun, sewn leather sandal of Tut, sandals of Yuya and Tjuya, red shoes and a shabti box for Pakhuru wearing a shoes [7]. Mark (2017) declared that sandals of ancient Egyptians were made of wood, papyrus, leather or a combination of them. He mentioned that the tomb of Tutankhamun housed 93 pairs of sandals in different styles with one gold sandal [8].

II. FOOTWEAR IN EARLY DYNASTIC

The ancient Egyptians practiced manufacturing and using footwear more than 5000 years ago during the Early Dynastic Period. The proof of this statement is depicted from the siltstone palette of Narmer, the founder of the 1st Dynasty (his reign started 3100 BC) [9]. The evidence here is from the 640 mm height stone palette of King Narmer in display in the Egyptian Museum at Cairo and shown in Fig.1 [10]. The palette shows the King smiting the head of an Egypt enemy while the other dead enemies are underneath his feet. A bearer is carrying his sandals to be ready for him when finish destroying Egypt's enemies.



The King *The sandal bearer*
Fig.1 Narmer palette from 1th Dynasty [10].

III. FOOTWEAR IN OLD KINGDOM

There is a sample of reed sandal from the 3rd Dynasty from the reign of King Djoser (2686-

2667 BC). The sandal is a sandal for the left leg and has a deteriorated top parts. It is a standard design of the sole suitable for the human foot.



Fig.2 Woven reed sandal from 3rd Dynasty [11].

IV. FOOTWEAR IN MIDDLE KINGDOM

We have a number of samples exploring the development of footwear during the Middle Kingdom (2050-1800 BC). The footwear examples during this period are presented as follows:

- The first example is a pair of sandals scene between two columns on the sarcophagus of Royal Wife Ashayet of King Mentuhotep II of the 11th Dynasty (2061-2010 BC) in display in the Egyptian Museum at Cairo and shown in Fig.3 [12]. The scene depicts the appreciation of ancient Egyptians to footwear as a daily life activity.



Fig.3 Pair of sandals scene from 11th Dynasty [12].

- The second example is a 245 mm length pair of sandals from the Middle Kingdom (2055-1773 BC) in display in the Liverpool Museum, Liverpool, UK) and shown in Fig.4 [13]. The

pair of sandals was produced wood and gesso. The straps may be produced from leather.



Fig.4 Pair of sandals from Middle Kingdom [13].

- The third example is a pair of sandals for Mesehti, the Mayor of Asyut during the 11th Dynasty (2000 BC) in display in the Egyptian at Cairo and shown in Fig.5 [14]. The sandal was produced from wooden soles and white leather straps. The straps was guided by two vertical poles near the back of the sandal while there was no pole at the strap front end.



Fig.5 Pair of sandals from 11th Dynasty [14].

- The fourth example is a wooden statue for Imerytebes, the Priestess of Amun during the 12th Dynasty (1991-1802 BC) in display in the Leiden Museum, Leiden, Holland and shown in Fig.6 [15]. The statue depicted the Priestess wearing a pair of sandals having decorated- colored leather strands.
- The fifth example is a pair of wooden sandals from the 12th-13th Dynasties (1985-

1650 BC) sold by Christies on October 2010 at London for 9,026 US\$ and shown in Fig.7 [16]. The leather straps were supported near the end of the sandal by two split poles simulating a human foot for better fixation and stability during sandal use in a brand new mechanical design.



Fig.6 Pair of sandals from 12th Dynasty [15].



Fig.7 Pair of sandals from 12th -13th Dynasties [16].

V. FOOTWEAR IN SECOND INTERMEDIATE PERIOD

From the Second Intermediate Period (1802-1550 BC) we have a 253 mm length pair of sandals for Sebekhotep I the founder King of the 13th Dynasty (1803 BC) in display in the British Museum and shown in Fig.8 [17]. The sandal was produced using decorated-wooden soles and leather

straps. The straps were supported using three vertical poles, one in the front and two near the ends of the sandal in a brand new mechanical design.



Fig.8 Pair of sandals from 13th Dynasty [17].

VI. FOOTWEAR IN NEW KINGDOM

We are now presenting footwear industry during the most richest and strongest kingdom during the whole ancient Egyptian history. Therefore, we expect to get outstanding and elaborated designs for footwear as will be depicted by the following examples:

- The first example is a papyrus fibre sandal from Early 18th Dynasty (1580-1479 BC) in display in the Metropolitan Museum of Art and shown in Fig.9 [18]. The sandal was produced using the coiling technique used in the basketry industry [19]. The three branches strap ends are joint directly to the sole of the sandal without need to intermediate poles as in the designs in Fig.8. Even though this sandal was produced from a plant fibre, it looks neat, well produced and in a good condition after more than 3480 years.



Fig.9 Pair of sandals from Early 18th Dynasty [18].

- The second example is children sandals from the New Kingdom (1570-1069 BC) in display in the Vatican Museum at Italy and shown in Fig.10 [20]. Probably they were produced using palm leaves. It is clear from Fig. 10 that there was three different sizes of the children sandals meaning that some children in ancient Egypt used sandals during their daily life.



Fig.10 Children sandals from 18th Dynasty [20].

- The third example is a leather-eared-sandals from the New Kingdom (1570-1069 BC) in display in the Medelhavsmuseet Museum, Stockholm, Sweden and shown in Fig.11 [5]. Its design is similar to that in Fig.9 except the material which was leather.



Fig.11 Leather sandals from the New Kingdom [5].

- The fourth example ia a 254 mm length pair of plaited reed sandals from the 18th Dynasty (1550-1295 BC) was in display by Sands of Time for sale at a price of 19,500 US\$ and shown in Fig.12 [21]. The sole was

sewn from reed while some of the straps are missing.



Fig.12 Plaited sandal from 18th Dynasty [21].

- The fifth example is a pair of reed shoes from the New Kingdom (1550-1070 BC) from the collections of Major Myers and shown in Fig.13 [22]. This is the first shoes appeared during the New Kingdom more than 3100 years ago. It was sewn using reed, open from the top and had a single-loop tie to keep the shoes secured on the foot.



Fig.13 Reed shoes from 18th Dynasty [22].

- The sixth example is a 214 mm length pair of sandals from the 18th-19th Dynasties (1550-1186 BC) in display in the Museum of Fine Arts at Boston and shown in Fig.14 [23]. This wonderful sandal was produced from palm leaves (or reed) and straw. The straps were directly joined to the sole without any poles. The front of the sole was slightly raised from the ground level.
- The seventh example is a papyrus shoes from the 18th Dynasty (1543-1292 BC)

shown in Fig.15 [24]. This is a unique design in which the front of the sole took the shape of a tongue of decreasing width was turned back to reach the straps of the shoes. I could not trace its present location !!.



Fig.14 Sandals from 18th -19th Dynasties [23].



Fig.15 Papyrus shoes from 18th Dynasty [24].

- The eighth example is a 198 mm pair of sandals for Pharaoh Amenhotep I of the 18th Dynasty (1524-1503 BC) in display in the Metropolitan Museum and shown in Fig.16 [25]. This sandal model was produced from stained calf skin and had a very thin sole having a thickness of only 2 mm. The straps were directly joined with the sole without any poles. .



Fig.16 Calf skin sandals from 18th Dynasty [25].

- The ninth example is a scene of a sandal maker from the tomb of Vizier Rekhmire of the 18th Dynasty (1479-1398 BC) shown in Fig.17 [18]. The figure depicts the footwear maker setting on a stool and working in assembling a sandal using his tools shown in the scene. He is using an inclined stand to support the sandal while working in it.



Fig.17 Footwear maker from 18th Dynasty [18].

- The tenth example a more detailed scene for footwear production from the tomb of Vizier Rekhmire of the 18th Dynasty (1479-1398 BC) and shown in Fig.18 [5]. Two workers are preparing the leather and tanning it, while three workers are working in sandals production. The produced soles are stacked in one location to be ready for the next stage.



Fig.18 Footwear workshop from 18th Dynasty [5].

- The eleventh example is a 264 mm golden Royal sandals from the reign of Pharaoh Thutmose III of the 18th Dynasty (1479-1423 BC) in display in the Metropolitan

Museum of Art and shown in Fig.19 [18]. They were produced from pure gold using multiple processes such as metal casting and sheet forming. The straps were wide and secured to the sole through three poles, one near the front and two near the back.



Fig.19 Golden sandals from 18th Dynasty [18].

- The twelfth example is a 304 mm pair sandals from the reign of Pharaohs Amenhotep III (1390-1352 BC) of the 18th Dynasty in display in the Metropolitan Museum of Art at NY and shown in Fig.20 [26]. It was produced from plaited grass and reed, while the toe and sides were produced from papyrus. Even though this sandal was produced from plant materials it looks very neat and in a good condition after more than 3360 years. The straps were joined directly to the soles without poles.



Fig.20 Plant sandals from 18th Dynasty [26].

- The thirteenth example is a scene for Pharaoh Tutankhamun between two deities (1332-1323 BC) in display in his tomb at

Thebes and shown in Fig.21 [27]. The pharaoh was shown wearing a white straps sandals. It is not strange that the artist selected a white color for the Pharaoh's sandals. The Pharaoh's tomb contained 10's of sandals and shoes of the Pharaoh with different designs and colors.



Fig.21 White strap sandals from 18th Dynasty [27].

- The fourteenth example is a pure pair of golden sandals for Pharaoh Tutankhamun (1332-1323 BC) in display in the Egyptian Museum at Cairo and shown in Fig.22 [28]. The straps were joined directly to the soles and the sole surface was roughened specially near the end to prevent unstable use of the sandals. This was the thinking of the mechanical engineers in ancient Egypt more than 3320 years ago. Besides all the surfaces are rounded to prevent any injury during use. Technology we are missing nowadays.



Fig.22 Golden sandals from 18th Dynasty [28].

- The fifteenth example is gold inlaid wooden sandals of Pharaoh Tutankhamun from the 18th Dynasty (1332-1323 BC) in display in the Egyptian Museum and shown in Fig.22 [29]. This piece represents the top technology in the ancient Egyptian footwear production. The designer used a cheap material for the sole (wood) but covered it completely through inlay with gold and another colored materials in a wonderful scenes on all the elements of the sandals.



Fig.23 Golden-inlaid sandals from 18th Dynasty [29].

- The sixteenth example is a scene for Pharaoh Ramses II of the 19th Dynasty (1279-1213 BC) smiting the heads of Egypt's enemies in display in one of his temples and shown in Fig.24 [30]. The Pharaoh is wearing a pair of sandals with white straps.

VII. THIRD INTERMEDIATE PERIOD FOOTWEAR

The production of footwear during this Period is depicted by two examples from the 2st and 22nd Dynasties as presented as follows:

- The first example a 235 mm pair of golden sandals for Pharaoh Psusenes I from the

21st Dynasty (1007-1001 BC) in display in the Egyptian Museum at Cairo and shown in Fig.25 [31]. This is a brand new design of sandals of ancient Egypt. It was produced from a pure gold sheet. The front of the sole was turned back while the straps were extremely wide. The back ends of the straps were connected to the sole through vertical poles. The front connection of the straps to the soles is not clear in the image because of the turned-back sole.

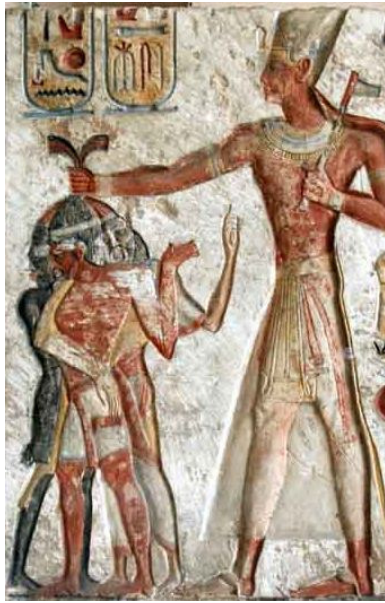


Fig.24 Scene of Ramses II from 19th Dynasty [30].



Fig.25 Golden sandals from 21st Dynasty [31].

- The second example is a golden pair of sandals for Pharaoh Sheshonq II from the 22nd Dynasty (887-885 BC) in display in the Egyptian Museum at Cairo and shown in Fig.26 [32]. This is again a new design for the Royal Egyptian sandals. The straps were designed as a two fork-elements, one element joined with the sole and the other was joined with first one and the toe. The front end of the sole was thinned gradually until its connection with first fork-element.



Fig.26 Golden sandals from 22nd Dynasty [32].

VIII. LATE PERIOD FOOTWEARS

We have two examples of the footwear industry of the ancient Egyptians during the late period presented as follows:

- The first example is a 260 mm striped woven reeds sandals from the Late Period (664-332 BC) in display in the Museum of Fine Arts at Boston and shown in Fig.27 [33]. The soles were decorated by horizontal bands in two colors. The strips .The strips were joined directly with the soles without poles.
- The second example is a leather sandal from Late Period (600-400 BC) in display in the Bata Shoe Museum at Toronto, Canada and shown in Fig.28 [34]. The sandals are of the striped type joined directly to the soles

without special poles to raise the levels of the strips.



Fig.27 Striped sandals from Late Period [33].



Fig.28 Leather sandals from the Late Period [34].

IX. CONCLUSIONS

- The paper investigated the evolution of Mechanical Engineering in ancient Egypt through the footwear industry over a time period from the 1st Dynasty to the Late Period.
- The ancient Egyptians registered the use of footwear on palette, sarcophagus, tomb walls statues and actual footwear left in the tombs..
- The first authorized sandal appeared during the 1st Dynasty in King Narmer palette.
- Woven reed sandals appeared in the 3rd Dynasty.

- Stripped sandals appeared during the Middle Kingdom with and without strips-raising poles.
- Striped sandals continued to appear with raising poles during the 13th Dynasty.
- They produced sewn plant sandals with neat designs and production during the 18th Dynasty.
- They used various materials in producing their footwear such as: reed, papyrus, palm leaves, palm fibre, halfa grass, wood, leather and gold.
- Different sizes of children sandals appeared during the 18th Dynasty meaning that their children used footwear from more than 3300 years.
- Leather eared sandals appeared during the New Kingdom.
- They designed and produced sewn reed shoes open from the top with single loop tie during the New Kingdom.
- Woven papyrus shoes with multi-loop ties and inverted tongue appeared during the 18th Dynasty.
- They designed and produced shoes with and without front tongue.
- They registered footwear workshops during the 18th Dynasty.
- They produced Royal golden sandals during the 18th, 21st and 22nd Dynasties.
- They produced sandals in the 18th Dynasty using wood inlaid by gold and other materials in wonderful patterns.
- They produced men sandals having length, L in the range: $198 \leq L \leq 304$ mm.

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