

MECHANICAL ENGINEERING IN ANCIENT EGYPT, PART 104: MORE ADHESIVE APPLICATIONS

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Article Received on 20/10/2022

Article Revised on 10/11/2022

Article Accepted on 30/11/2022

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ABSTRACT

The paper presents the use of adhesives in four industries: furniture, stone jars, axes and arrows. Examples of each industry from various ancient Egyptian time spans are highlighted with investigation of the use of adhesives and its possible type. The present location of each artifact is traced besides its production date if known. This work is a continuation of an intensive work about the same subject outlined in

part 103 of the series of Mechanical Engineering in ancient Egypt studied by the author.

KEYWORDS: Mechanical engineering in ancient Egypt, adhesives industry, wood furniture industry, stone jars industry, axes industry, arrows industry.

INTRODUCTION

The ancient Egyptians found numerous applications for adhesives in too many industries. They could apply natural and synthesis adhesives for durable work and prolonged use that sustained for thousands of years without losing its characteristics.

Petrie (1917) presented in his book about tools and weapons a large number of axes with various designs from ancient Egypt. The models he presented were with or without holes for handle hafting.^[1] Lucas (1934) gave examples of wood works from the Old Kingdom, Middle Kingdom and New Kingdom and outlined the extensive use of mortise and tenon joints in some wooden products without evidence of glue. He analysed the eye of the wooden statue of 'Sheikh el-Belad' and considered his statue as one of the highly skilled wood carving. He

authorized the use of glue during the 18th Dynasty in many of the objects of Pharaoh Tutankhamun used to fasten wood together and to fix ebony and ivory inlay in place.^[2] Clark, Philips and Staley (1974) investigated the ancient Egyptian bows and arrows during Predynastic and Early Dynastic Periods. They presented arrowheads of bone, stone, fish mandibles and metals. They outlined that the ancient Egyptians used adhesive, papyrus and cloth for binding the heads to the arrow shaft.^[3] Edinborough (2005) in his Ph. D. Thesis outlined three methods for hafting Mesolithic arrowheads.^[4]

Rifai and El-Hadidi (2010) investigated three gilded wood samples from the tomb of Pharaoh Tutankhamun of the 18th Dynasty. Their analysis showed that the ancient Egyptians in the 18th Dynasty used linen textile glued using animal glue to the wood base and the next gesso layer and a gesso layer and a binding medium between the textile layer and the gilding layer^[5]. Hassaan (2016) presented a porphyry jar from the 2nd Dynasty of Egypt having two golden handles secured to the jar body using an adhesive which was an innovation and an outstanding design^[6]. Patricio (2020) focused his paper on the solid ebony chair of Pharaoh Tutankhamun from the 18th

Dynasty, chairs of Queen Hetepheres from the 4th Dynasty. He studied the materials, techniques, similarities and dissimilarities between the studied chairs.^[8]

Hassaan (2022) studied the adhesive applications in ancient Egypt covering a time span from Predynastic to Late Period. He investigated the use of adhesives in a number of industries including amulets, pendants and pectorals, bracelets and armbands, finger rings, mummy masks, statues and coffins and cartonnage industries. He investigated the inlays used in these industries and the adhesive used outlining their dates.^[9]

Adhesives in Furniture Production

The ancient Egyptians could establish well authorized and organized furniture industry since the time of the 1st Dynasty.^[10] They used adhesives to strengthen their wooden joints between furniture elements as will be investigated in the following examples:



Figure1: Bed frame from the 1st Dynasty^[12].

The first example is the use of dovetail joints in the furniture industry originated during the 1st Dynasty of ancient Egypt. It was claimed that once the wood dovetail joint was glued, it didn't require any mechanical fastener.^[11] An example of furniture's using dovetail joints from the 1st Dynasty (3100-2900 BC) is a wooden bed frame in display in the Manchester Museum and shown in Fig.1.^[12] It has the features:

- The frame sides are straight.
- It has four legs.
- Dovetail joints connect the four sides of the frame and the four legs to the frame.
- Strengthening the joint using an adhesive secures the structure of the frame.
- Most probably, the adhesive used was animal glue known in ancient Egypt since the Neolithic Period.^[13] or a resin known since the same period.^[14]

The second example is a wooden stool from the 12th Dynasty in display in the Metropolitan Museum of Art, New York and shown in Fig.2.^[15] It has the features:

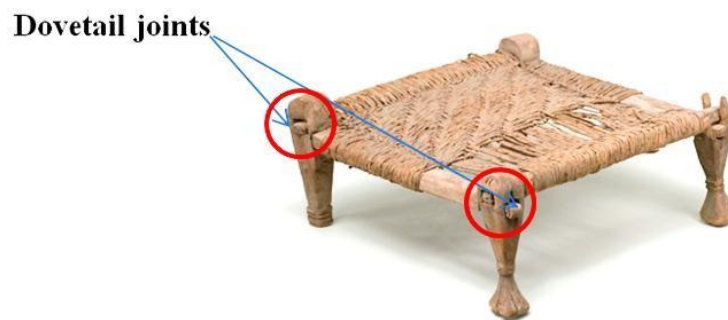


Figure 2: Wooden stool from the 12th Dynasty.^[15]

- The frame sides are straight.
- It stool has four legs.
- Dovetail joints are used in a different way than the design in Fig.1.
- The frame sides are joined to the legs using dovetail joints.
- Strengthening the joint using an adhesive secures the structure of the frame.
- Most probably, the adhesive used was animal glue known in ancient Egypt since the Neolithic Period.^[13] or plant resin known since the same period.^[14]

The third example is a wooden jewellery box of Tutankhamun, the 13th Pharaoh of the 18th Dynasty (1332-1323 BC) in display in the Egyptian Museum, Cairo and shown in Fig.3.^[16] It has the features:



Figure 3: Wooden jewelry box from the 18th Dynasty.^[16]

- The high production technology of carpentry work in the 18th Dynasty is clear in this Royal product.
- The idea of the product is quit new. The box took the shape of the Pharaoh's Cartouche.
- The cover is made of one piece with rounded corners following the rounding-corners of the design methodology of the mechanical engineering design in ancient Egypt.
- The cover is inlaid with ebony and ivory forming hieroglyphic letters inscribing the Pharaoh's name and title.^[16]
- Dovetail or mortise and tenon joints may be used in the body of the box. There is no sign of the joints connecting the sides of the box because of the fine production of the box.
- Strengthening the joint using an adhesive secures the structure of the box frame.
- Most probably, the adhesive used was animal glue known in ancient Egypt since the Neolithic Period,^[13] plant resin known since the same period.^[14] or a lime plaster used in ancient Egypt since Early 18th Dynasty (1400 BC).^[17]

The fourth example is an ebony chair of Tutankhamun, the 13th Pharaoh of the 18th Dynasty (1332-1323 BC) in display in the Egyptian Museum, Cairo and shown in Fig.4.^[18] It has the features:



Figure 4: Ebony chair from the 18th Dynasty.^[18]

- The chair is another indication of the high production technology of carpentry work in the 18th Dynasty.
- The chair back and side arm-supports were inlaid by ivory inlays of different sizes and designs. Here, adhesive application is due to secure the inlays in position.
- It was reported that the chair frame was assembled using four mortise and tenon joints with shoulder and the back and sides were also joined to the frame using mortise and tenon joints.^[8]
- Most probably, the adhesive used was animal glue known in ancient Egypt since the Neolithic Period.^[13] plant resin known since the same period.^[14] or a lime plaster used in ancient Egypt since Early 18th Dynasty (1400 BC).^[17]

Adhesives in Stone Jars Production

The use of adhesives in Stone jars production looks awkward because of the nature of the materials used in this production. However for the ancient Egyptians nothing is awkward. The proof of this is the following two examples

The first example is a porphyry jar produced during the 2nd Dynasty (2890-2686 BC) in display in the British Museum and shown in Fig.5.^[91,02] This jar has the features:

- The jar has a semi-spherical shape.
- It has two golden flanged semi cylindrical handles.
- The flanges were slightly curved to match the external surface of the jar.
- The handles were secured to the jar-body using adhesive.
- The adhesive used may be animal glue known in ancient Egypt since the Neolithic Period^[13] or a plant resin known since the same period.^[14]



Figure 5: Porphyry jar from the 2nd Dynasty. ^[19,20]

The second example is a perfume alabaster jar for Akhenaten, the 10th Pharaoh the 18th Dynasty (1351-1334 BC) in display in the Metropolitan Museum of Art and shown in Fig.6^[01,22] This jar has the features:

- The jar has an ellipsoid shape with tight cover to suit perfume storage.
- It has a short neck and a long curved surface conical base.
- The jar was decorated by a lotus flower on its lower surface near the long base and a figurine of a Princess striding over the flower.
- The lotus flower was inlaid by stones having blue, green and brown colors.
- The figurine has a black hair and a brown body.
- The inlay stones may be: obsidian for the black color, quartz for the brown color, feldspar for the light green color and lapis lazuli for the blue color. The origin of those stones as used by the ancient Egyptians was identified in a previous work.^[9]
- The adhesive used to secure the flower and the Princess figurine may an animal glue known in ancient Egypt since the Neolithic Period,^[13] plant resin known since the same period^[14] or lime plaster which was known in ancient Egypt during the 18th Dynasty.^[17]

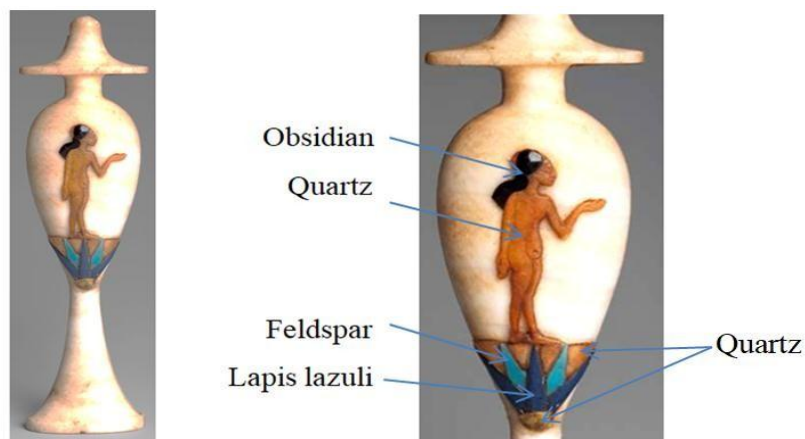


Figure6: Alabaster perfume jar from the 18th Dynasty ^[21,22].

Adhesives in Axes Production

The ancient Egyptians used axes for both civilian applications and also as a military weapon.^[23] The civilian use of axes in the ancient Egyptian societies started since the time of Naqada.^[24] The military use of axes as a weapon started early during the Predynastic Periods (6000-3150BC).^[25] Adhesive use in civilian and military applications of axes is illustrated in the following examples

The first example is a bronze axe head from the First Intermediate-Early Middle Kingdom Periods (9th – 12th Dynasties, 2100-1950 BC) in display in the Metropolitan Museum of Art and shown in Fig.7.^[26] This axe head has the features

- The axe has a semi-circular bronze blade.
- The axe head has a height/width ratio of 0.825.
- The head has two wedges at the ends of its top part and three small holes in its top part to support the cords used to secure the blade to its handle.
- Probably an adhesive was used to secure the blade with the axe-handle.
- Probably the adhesive used was animal glue known in ancient Egypt since the Neolithic Period^[13] or a plant resin known in ancient Egypt since the Neolithic Period.^[14]



Figure 7: Axe head from 9-12th Dynasties.^[26]

The second example is an axe from the 12th Dynasty (1802-1762 BC) with copper blade and wooden handle shown in Fig.8.^[27] This axe has the features:



Figure 8: Axe from 12th Dynasty.^[26]

- The axe has a semi-circular copper blade.
- The axe-handle was produced from wood with a wedge at its end to prevent slipping of the axe in the hand of its user.
- The handle was slotted at the blade end to insert the metallic blade.
- An adhesive was used to secure the blade with the handle.
- The adhesive used was animal glue.^[26] known in ancient Egypt since the Neolithic Period.^[13]
- The third example is a bronze model axe head from the Second Intermediate Period (14th-17th Dynasties, 1640-1550 BC) in display in the Metropolitan Museum of Art and shown in Fig.9.^[28] This axe has the features:
 - The axe head has concave lateral surfaces and circular-sector cutting edge.
 - The sharp edges at the other end of the blade help using cords to secure the blade with its handle.
 - The handle was slotted at the blade end to insert the bronze blade.
 - Probably an adhesive was used to secure the blade with the axe-handle.
 - Probably the adhesive used was animal glue known in ancient Egypt since the Neolithic Period^[13] or a plant resin known in ancient Egypt since the Neolithic Period.^[14]



Figure 9: Axe head from 14th – 17th Dynasties.^[28]

The fourth example is a ceremonial axe belonged to Ahmose I, 1st Pharaoh and founder of the 18th Dynasty (1549-1524 BC) in display in the Metropolitan Museum of Art and shown in Fig.10.^[23] This axe has the features:

- The design of the axe blade is similar to that of the Second Intermediate Period shown in Fig.9.
- As a Royal ceremonial axe, its handle was gilded and the blade was decorated by Deities symbols and hieroglyphic text on gilded background.^[29]
- A cord was used to secure the blade with the handle externally.
- Probably an adhesive was used to secure the blade with the axe-handle.

- Probably the adhesive used was animal glue known in ancient Egypt since the Neolithic Period,^[13] a plant resin known in ancient Egypt since the Neolithic Period.^[14] or lime plaster which was known in ancient Egypt during the 18th Dynasty,^[17]



Figure 10: Ceremonial axe from the 18th Dynasty.^[29]

Adhesives in Arrows Production

The ancient Egyptians used arrows as for hunting and warfare purposes since 3050 BC (during Naqada III Period)^[30] Adhesive use in the production of arrows in ancient Egypt is illustrated in the following examples

The first example is arrows from the Predynastic Periods, probably from the time of Naqada III (3200-3000 BC) in display in the Egyptian Museum, Cairo and shown in Fig.11.^[31] These arrows have the features:

- Each arrow is composed of three elements: body (wood), middle element (probably reed) and tip (flint).
- The material for the middle element is hollow, thus allowing the stone tip to fit in and secured using an adhesive.
- The adhesive used may be animal glue known in ancient Egypt since the Neolithic Period
- ^[13] or plant resin known since the same period.^[14]



Figure 11: Arrows from Naqada III.^[31]

The second example is arrows from the 12th Dynasty (1991-1802 BC) in display in the British Museum, London and shown in Fig.12.^[32] These arrows have the features:

- Each arrow is composed of two elements: body (reed) and tip (flint).

- The material for the body is hollow, thus allowing the stone tip to fit in and secured using an adhesive.
- The adhesive used may be animal glue known in ancient Egypt since the Neolithic Period^[13] or plant resin known since the same period.^[14]
- The third example is an arrow from the reign of Hatshepsut, the 5th Pharaoh of the 18th Dynasty (1479-1458 BC) in display in the Metropolitan Museum of Art, New York and shown in Fig.13.^[33] This arrow has the features:
- Each arrow is composed of three elements: body (wood), middle element (reed) and tip (quartz). Here, the mechanical designer replaced flint used since the Predynastic Periods with Quartz.
- The material for the middle element is hollow, thus allowing the stone tip to fit in and secured using an adhesive.
- The adhesive used may be animal glue known in ancient Egypt since the Neolithic Period,^[13] plant resin known since the same period.^[14] or lime plaster applied since Early 18th Dynasty.^[17]



Figure 12: Arrows from the 12th Dynasty.^[32] Figure 13: Arrow from the 18th Dynasty.^[33]

CONCLUSION

- The paper presented the adhesive use in the furniture, stone jars, axes and arrows production in ancient Egypt during a time span from the Predynastic Period to the 18th Dynasty of the New Kingdom.
- The dates presented in the paper were authorized by earthed artifacts.
- The ancient Egyptians used adhesives to strengthen wooden bed-frames since the 1st Dynasty, wooden stool-frames since the 12th Dynasty, boxes-body since the 18th Dynasty and chairs-frame since the 18th Dynasty.
- They used adhesives to secure golden handles to a stone jar in the 2nd Dynasty and inlays to a stone perfume jar in the 18th Dynasty.
- They used adhesives to secure axe-handle to its blade during the First Intermediate Period to the 18th Dynasty Periods for both civilian and military axes.

- They used adhesives to secure arrows-tips to a cylindrical reed since the time of Naqada III (with flint tips) and continued to use this technique down to the 18th Dynasty (with quartz tips).
- Probably, the adhesives used were: animal glue, plant resin or lime plaster.
- 13th examples were presented to authorize the use of adhesives in the four industries investigated in the paper.

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