

## Mechanical Engineering in Ancient Egypt, Part 82: Boats Industry during the New Kingdom and Late Period

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### ABSTRACT

The refrigerating machines are used extensively in our life, with their use they are losing a quantity of thermal energy which is very important without being properly exploited. To study these machines, we chose a Household refrigerator to perform experimental tests. The investigation results showed that the domestic refrigerator work normally using waste heat recovery for water heating. The water temperature in the tank reached 50°C, with a continuous use of the domestic refrigerator the temperature will be better. The values of different thermo-physical properties was determined by using EES software based on relationship between pressure and temperature obtained from experiment that has been conducted.

**Keywords:** Numerical investigation, Water Cooled condenser, water tank, condenser design.

### INTRODUCTION

This research paper is the 82 paper in a series of research papers aiming at investigating the evolution of Mechanical Engineering in ancient Egypt through studying the production of boats in ancient Egypt during a historical period from the New Kingdom to the Late Period.

Lippiello (2004) in her Master of Arts Thesis presented a colored scene of the sun god's boat from the papyrus of Ani from the 20<sup>th</sup> Dynasty, a colored scene showing four boat rudders representing the cardinal directions from the 18<sup>th</sup>-19<sup>th</sup> Dynasties. She presented also a colored scenes for two boats each having two steering oars from the tomb of Ramses VI of the 20<sup>th</sup> Dynasty, a colored scene showing Ani rowing his boat in his funerary papyrus boat from the 19<sup>th</sup> Dynasty, boat model for Pharaoh Tutankhamun in the Egyptian Museum at Cairo, a boat model with papyriform finals from Tutankhamun tomb, a colored scene for a sail-boat from the Book of Dead written by Nu of the 18<sup>th</sup> Dynasty [1].

Gilbert (2008) in her book about the seapower of the ancient Egyptians presented two boat models from Meketre boat-collection in the Egyptian Museum at Cairo, scene of Pharaoh Hatshepsut ships to Punt from the 18<sup>th</sup> Dynasty, scene of warships of Pharaoh Ramses III from the 20<sup>th</sup> Dynasty in Medinet Habu, sailing vessel from

the tomb of Rekhmire from the 18<sup>th</sup> Dynasty and colored scene for fighting training papyrus boats [2]. Creasman and Doyle (2010) in their study of the overland boat transportation during the Pharaonic Period presented a scene for a funerary procession from the 18<sup>th</sup> Dynasty, ascene for te construction of a funerary-shrine on a boat from tomb of Usehat of the 19<sup>th</sup> Dynasty, funerary boat scene from the tomb of Vizier Antefoker of the 12<sup>th</sup> Dynasty, boat scenes from the tomb of Huy from the 18<sup>th</sup> Dynasty, a colored scene of a funerary boat on a wagon from the tomb of Sobeknakht II, Governor of El-Kab during the 16<sup>th</sup> and 17<sup>th</sup> Dynasties, and a wagon carried boat scene from the tomb of Petosiris, High Priest during the 28<sup>th</sup> Dynasty [3].

Vinson (2013) in his paper about the use of boats presented the funerary ship of King Khufu from the 4<sup>th</sup> Dynasty, scenes for transportation boats from the Old Kingdom, a scene for the naval battle against the Sea People in Medinet Habu during the reign of Pharaoh Ramses III of the 20<sup>th</sup> Dynasty [4]. Priskin (2016) presented the circular zodiac in Dendera Temple including scenes for a number of boats, scenes in the astronomical ceiling of Esna, a scene of the zodiac at Kom ed-Deir, astronomical diagram in the Ramesseum, astronomical diagram of Pharaoh Seti I of the 19<sup>th</sup> Dynasty (all including boat scenes) [5].

Ismail, Abdrabou and Abdallah (2016) presented a non-destructive analytical study and the conservation processes of Pharaoh Tutankhamun painted boat model. The presented photos for the 0.934 m length painted wooden boat model before and after conservation [6]. Mark (2017) in his study of the ship depiction in the tomb of Nebamun from the 18<sup>th</sup> Dynasty presenting a destroyed scene for the studied ship. He presented also a rowing war-boat in Medinet Habu, a Nile boat scene in the tomb of Rekhmire from the 18<sup>th</sup> Dynasty and a scene of Pharaoh Hatshepsut ship from the 18<sup>th</sup> Dynasty [7]. Facts and Details (2018) wrote an article about boats and ships in ancient Egypt. They outlined that the ancient Egyptians used vessels powered by sails, oars or both and presented models for boats from the 12<sup>th</sup> Dynasty, Middle Kingdom, funerary boats, colored scenes for ships, wagon-carried boat model, transportation boats, scenes of seafaring ships and war boats from the New Kingdom [8]. Freeman (2019) in his article about the ancient Egyptians as model builders presented boat models of different designs, boats from Meketre tomb including papyrus fishing boats [9]. Hassaan (2019) investigated the boats

industry during a historical period from the Predynastic to the Middle Kingdom. He presented a large number of boat scenes and models outlining the type, material, powering of each boat and its present location [10].

### **NEW KINGDOM BOATS INDUSTRY**

The New Kingdom Period of ancient Egypt comprised the 18<sup>th</sup> to the 20<sup>th</sup> Dynasties over a time period from 1570 to 1077 BC [11]. This is one of the most powerful periods during Egypt's ancient history where we expect to see highly professional boat industry and boat models of outstanding features as will be depicted in the following examples:

The first example is a colored scene for a transportation boat from the tomb of Unsou from the 18<sup>th</sup> Dynasty (1567-1320 BC) in display in the Louvre Museum at Paris and shown in Fig.1 [12].

It depicts the loading of a specially designed transportation boat with grains. Tomb robberies and enemies of Egypt didn't leave even the tombs by destroying their wonderful walls painted by our grandfathers.



**Figure1.** Boat scene from the tomb of Unsou from the 18<sup>th</sup> Dynasty [12].

The second example is a silver boat model for Queen Ahhotep I, mother of Pharaoh 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.2 [13]. The boat reflects an asymmetrical design for the boat which was powered by ten rowers in two rows and one holding the steering oar in the front of the boat.



**Fig2.** Silver boat model of Queen Ahhotep I from the 18<sup>th</sup> Dynasty [13]

The third example is a funerary boat model from the 18<sup>th</sup> Dynasty (1543-1292 BC) in display in the British Museum and shown in Fig.3 [14]. It has a symmetrical design and steered by two long oars in the front of the boat and had a

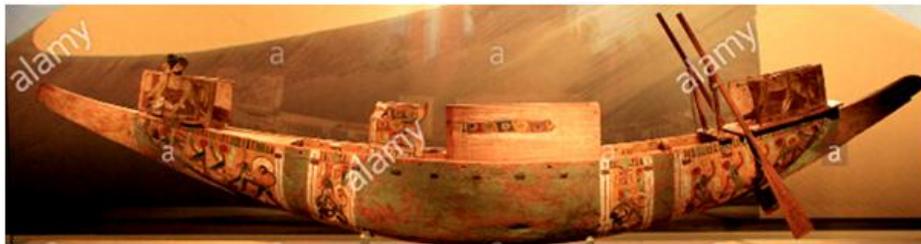
funerary shrine in the middle of the deck having four colored and decorated columns. The model depicted two ladies looking after the mummy and two men sitting on a chair.



**Figure3.** Funerary boat model from the 18<sup>th</sup> Dynasty [14].

The fourth example is a painted wooden boat model of Pharaoh Amenhotep II, the 7<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty (1425-1398 BC) in display in the Egyptian Museum at Cairo and shown in Fig.4 [15]. The model depicted a boat of the

symmetrical type steered by two long oars and had four cabinets of different dimensions. The hull was decorated by colored scenes for one of ancient Egyptian Deities smiting enemies of Egypt.



**Figure4.** Wooden boat model of Amenhotep II from the 18<sup>th</sup> Dynasty [15].

The fifth example is a hunting scene using a boat for scribe Menna during the reign of Thutmose IV, the 8<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty (1398-1388 BC) from Menna's tomb

number TT69 shown in Fig.5 [16]. The scene depicts two papyrus boats of the asymmetrical type with one end simulating a lotus flower.



**Figure5.** Hunting and fishing boat scene in Menna's tomb from the 18<sup>th</sup> Dynasty [16].

The sixth example is a colored boat scene from the tomb of Huy, the Viceroy of Kush during the reign of Tutankhamun, the 13<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty (1332-1323 BC) shown in Fig.6 [17]. The scene depicts an asymmetrical

transportation boat with one end simulating a lotus flower. The boat had a number of cabinets and steered by two long oars joined to vertical poles near the stern of the boat and powered by rowers.



**Figure6.** Transportation boat scene in Huy's tomb from the 18<sup>th</sup> Dynasty [17].

## Mechanical Engineering in Ancient Egypt, Part 82: Boats Industry during the New Kingdom and Late Period

The seventh example is a wall engraving scene of an entertainment boat for General Paatenemheb and his wife in a boat during the reign of Akhenaten, the 10<sup>th</sup> Pharaoh of the 18<sup>th</sup> Dynasty (1351-1334 BC) shown in Fig.7 [18].



**Figure7.** Entertainment boat scene of General Paatenemheb from the 18<sup>th</sup> Dynasty [18].

The eighth example is a marsh hunting colored scene from the tomb chapel of Nebamun, Scribe and Grain Accountant during the 18<sup>th</sup> Dynasty (1350 BC) in display in the British Museum at London (!! ) and shown in Fig.8 [19]. The scene depicts a papyrus symmetrical boat with lotus-blossom ends. It had no oars for rowing or steering. The owner was accompanying his family with him on the boat while hunting birds.



**Figure8.** Hunting boat scene of Scribe Nebamun from the 18<sup>th</sup> Dynasty [19].



**Figure9.** Alabaster ibex boat model of Tutankhamun from the 18<sup>th</sup> Dynasty [20].

## Mechanical Engineering in Ancient Egypt, Part 82: Boats Industry during the New Kingdom and Late Period

The tenth example is a symmetric wooden decorated boat model of Pharaoh Tutankhamun from the 18<sup>th</sup> Dynasty (1332-1323 BC) in display in the Egyptian Museum at Cairo and shown in Fig.10 [21]. It carried three cabinets

on its deck, one large in the middle and two small ones near the bow and stern of the boat. It was steered by two long oar hinged with a vertical poles.



**Figure10.** Boat model of Tutankhamun from the 18<sup>th</sup> Dynasty [21].

The eleventh example is a symmetric sail boat model of Pharaoh Tutankhamun from the 18<sup>th</sup> Dynasty (1332-1323 BC) in display in the Egyptian Museum at Cairo and shown in Fig.11 [22]. It carried two cabinets (or shrines) on its

deck, one near the bow and the other near the stern of the boat. It was steered by one long oar hinged with a vertical pole. The boat was painted, decorated and steered using one long oar joined with a vertical pole.



**Figure11.** Boat model of Tutankhamun from the 18<sup>th</sup> Dynasty [22].

The twelfth example is an almost symmetrical boat scene from the tomb of Sennefer, the Mayor of Thebes during Pharaoh Amenhotep II from the 18<sup>th</sup> Dynasty (1425-1398 BC) and shown in Fig.12 [23]. It was powered by a sail

and a rowing team consisting of eight rowers, four from each side and steered by one long oar hinged with a vertical pole near the row. It had two small cabinets near the bow and stern.

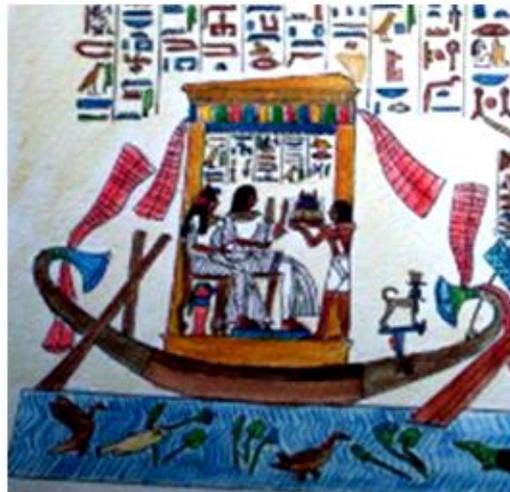


**Figure12.** Boat scene from Sennefer's tomb from the 18<sup>th</sup> Dynasty [23].

## Mechanical Engineering in Ancient Egypt, Part 82: Boats Industry during the New Kingdom and Late Period

The thirteenth example is a colored scene for a travelling boat from the tomb of Tia, the Overseer of the Treasury during the reign of Pharaohs Seti I and Ramses II from the 19<sup>th</sup> Dynasty (1290-1213 BC) and shown in Fig.13 [24]. The boat was of the symmetrical type with curved and turned back bow and stern taking the shape of a lotus flower. It was steered by one long oar hinged with a vertical pole near its stern. It had a large cabined (shrine) in its middle where the owner and his wife were

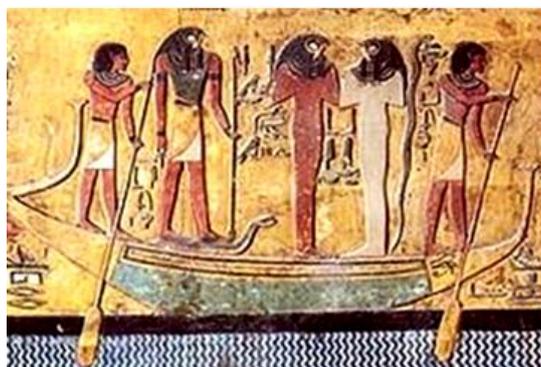
sitting beside each other and receiving offerings from one of their lovers. The boat was identified by flags two of them attached to the shrine and another two attached to the bow and stern of the boat. There was another identification in front of the shrine which was a lion statue on a stand. These outstanding features reflect the wealth of the owner and his wife. Beside his job as a Treasury Overseer, his wife Tia was a sister for the Great Pharaoh Ramses II and daughter of his father Pharaoh Seti I.



**Figure13.** Boat scene from Tia's tomb from the 19<sup>th</sup> Dynasty [24].

The fourteenth example is a colored scene for a boat from the tomb of Seti I, the 2<sup>nd</sup> Pharaoh of the 19<sup>th</sup> Dynasty (1290-1279 BC) and shown in Fig.14 [25]. The boat was of the asymmetrical

type with curved and turned stern and vertical bow both taking the shape of a lotus blossom. It was powered by two standing rowers and shown carrying a number of ancient Egypt Deities.



**Figure14.** Boat scene from the tomb of Set I from the 19<sup>th</sup> Dynasty [25].

The fifteenth example is a relief of a boat in the temple of Ramses II at Abydos from the 19<sup>th</sup> Dynasty (1279-1213 BC) shown in Fig.15 [26]. The boat scene depicts the steering mechanism of the boat where two steering oars were joined to two vertical poles with a helms man in the pose of the Pharaoh operating the steering oars.

was identified by its curved stern ended with a lotus blossom.

It may be a wonderful symbolic drawing meaning that Pharaoh Ramses II is guiding Egypt in its sail through the life ocean. The boat

The sixteenth example is a relief of asymmetric sacred barque of Osiris in the temple of Pharaoh Seti I completed by his son Pharaoh Ramses II at Abydos from the 19<sup>th</sup> Dynasty shown in Fig.16 [27]. The relief depicts the decoration of the barque ends with a collar from each end with a curved lotus flower with its stem at its stern and a Deity head replacing the lotus flower at its

## Mechanical Engineering in Ancient Egypt, Part 82: Boats Industry during the New Kingdom and Late Period

bow. It depicts also the steering oars joined to vertical poles near the stern end. It carried a large shrine with Priests around the shrine two

of them holding long stems with Deities on their tops.



**Figure15.** Boat scene in the temple of Ramses II from the 19<sup>th</sup> Dynasty [26].



**Figure16.** Barque scene in the temple of Seti I completed by Ramses II from the 19<sup>th</sup> Dynasty [27].

The seventeenth example is a relief of asymmetric Royal boat in the temple of Ramses III, the 2<sup>nd</sup> Pharaoh of the 20<sup>th</sup> Dynasty in Medinet Habu and shown in Fig.17 [28]. The relief depicts the Pharaoh rowing the boat using

one oar while the steering oar is behind him joined to a vertical pole. The boat was identified by curved stem-lotus flower simulators at its bow and stem.



**Figure17.** Royal boat relief in the temple of Ramses III from the 20<sup>th</sup> Dynasty [28].

The eighteenth example is a relief of colored asymmetric boat in the tomb of Ramses IV in the Valley of the Kings at Thebes, the 3<sup>rd</sup> Pharaoh of the 20<sup>th</sup> Dynasty (1155-1149 BC) and shown in Fig.18 [29]. The relief depicts an asymmetric boat identified by lotus-stem-flower

simulators at the bow and stern. The boat was steered by two steering oars near the stern joined to vertical poles. The scene depicts the Pharaoh saluting an ancient Egyptian Deity and a pilot in the front of the boat. The boat was shown dragged by four men using a rope.



**Figure18.** Boat relief in the tomb of Ramses IV from the 20<sup>th</sup> Dynasty [29].

### LATE PERIOD BOATS INDUSTRY

The Late Period of ancient Egypt comprised the 26<sup>th</sup> to 30<sup>th</sup> Dynasties over a time span from 664 to 332 BC [30]. The evolution of the boats industry during the Late Period of ancient Egypt will be depicted by the following examples:

The first example is a 194 x 270 mm wooden-boat building scene on a limestone panel from the 26<sup>th</sup> Dynasty (664-634 BC) in display in the Brooklyn Museum at New York and shown in Fig.19 [31]. The scene depicts three workers

working in building a wooden boat. One of them working on the hull while the second one may be working in the preparation of an oar joint. The third worker is doing something on the boat deck. It may be from a tomb or a temple. Nobody knows as it was stolen from Egypt and sold anywhere in the world destroying its history and the great history of ancient Egypt!!!!.



**Figure19.** Boat building scene from the 26<sup>th</sup> Dynasty [31].

The second example is a 330 mm length colored wooden boat model from the Late Period (664-332 BC) in display by an Italian Art Dealer and shown in Fig.20 [32]. The model depicted a boat of an asymmetric design with different ends at its bow and stern.

The bow took the shape of a jackal while the stern took the shape of a lotus flower. There was an open sided cabinet on the middle of the boat-deck with a roof simulating a Cartouche. There were four persons sitting on the deck. They may be four rowers and the pilot.

The third example is a 330 mm length colored wooden boat model from the Late Period (664-332 BC) and shown in Fig.21 [33]. The model depicted a boat of a symmetric design with similar ends at its bow and stern. The ends simulated a lotus flower.

There was an open sided cabinet on the middle of the boat-deck with a missing roof. There were three persons on the deck. They may be two sitting rowers and a standing pilot.



**Figure20.** Wooden boat model from the Late Period [32].



**Figure21.** Painted wooden boat model from the Late Period [33].

The fourth example is a 0.46 m length wooden sarcophagus fragment decorated by a boat scene from the Late Period (664-343 BC) was in display by Bonhams on 1<sup>st</sup> May 2013 for sale with an estimated price between 1900 and 2500

US \$ and shown in Fig.22 [34]. It was inscribed by a scene for a symmetric boat carrying four rowers (from each side). There was a steering oar near its stern and the ends took the shape of a lotus flower.



**Figure22.** Painted sarcophagus fragment with boat scene from the Late Period [34].

The fifth example is a symmetric boat model from the Late Period (664-250 BC) shown in Fig.23 [35]. The boat model carried four rowers (with missing oars) and a big jar on the boat deck.

of Pharaoh Psamtik I of the 26<sup>th</sup> Dynasty (664-610 BC) in display in the Metropolitan Museum of Art at New York (!!!) and shown in Fig.24 [36].

The sixth example is a transportation boat relief from the tomb of Nespekashuty during the reign

The boat was shown dragging another boat and having a curved stern with a lotus flower simulator.



**Figure23.** Painted boat model from the Late Period [35].



**Figure24.** Carved boat relief from the 26<sup>th</sup> Dynasty [36].

## CONCLUSION

- The paper investigated the evolution of mechanical engineering in ancient Egypt through studying the boats industry during the New Kingdom and Late Period.
- The ancient Egyptians registered using boats for the transportation of grains and designing the deck with great storage capacity during the 18<sup>th</sup> Dynasty of the New Kingdom.
- They build a boat model from silver for Queen Ahhotep I of the 18<sup>th</sup> Dynasty with details such as paddling and steering.
- They left models of funerary boats in their tombs with shrines on their decks.
- There boats were steered by one or two long oars joined to vertical poles flourished towards the bow or stern of the boat.
- The Pharaohs of the 18<sup>th</sup> Dynasty left wonderful decorated boat models in their tombs.
- Nobles of the 18<sup>th</sup> Dynasty used boats for fishing and bird-hunting.
- They designed and produced symmetric and asymmetric boats during the New Kingdom.
- They used boats with large storing capacities for goods transportation across the Nile.
- They used boats for entertainment and registered this as reliefs inside their tombs during the 18<sup>th</sup> and 19<sup>th</sup> Dynasties.
- Wonderful decorated alabaster and wooden boats were produced for Pharaoh Tutankhamun of the 18<sup>th</sup> Dynasty.
- They inscribed dual-powered boats using sails and paddling oars together in some of the Noble tombs.
- Boats were basic elements in the decoration and inscription of the New Kingdom tombs and temples.
- They registered the production of wooden boats on limestone panels during the 26<sup>th</sup> Dynasty of the Late Period.
- The bow and stern ends the boats took the shape of flowers or animals and sometimes humans.
- They continued to use shrines on boat-deck up to the Late Period.
- Symmetric boats with rowing team and oars-steering continued to be used during the Late Period.

- The boats industry during the Late Period suffered from great deterioration compared with that during the New Kingdom.

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