RESEARCH ARTICLE OPEN ACCESS

Mechanical Engineering in Ancient Egypt, Part 83: Seagoing Ships Industry

Galal Ali Hassaan
Department of Mechanical Design & Production, Faculty of Engineering,
Cairo University, Giza, Egypt
Email: galalhassaan@ymail.com

Abstract:

This paper is the 83rd research paper in a series investigating the evolution of mechanical engineering in ancient Egypt. It investigates the ship industry during a time span from Predynastic to Late Periods of ancient Egypt. It outlines evidences of using seagoing ships in ancient Egypt and how they navigated them. The location, type , steering, design are all investigated.

Keywords — **Mechanical engineering; ancient Egypt, seagoing ships industry, Predynastic to Late Periods.**

I. INTRODUCTION

This is the 83 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 production and use of seagoing ships in ancient Egypt.

Silva (2007) in his paper about shipbuilding in the ancient Mediterranean pointed out that used unlocked mortise and tenon joints in building the Khufu ship and the 1850 BC Dahsur boats [1]. Gilbert (2008) in his book about the ancient Egyptian seapower presented scenes for Pharaoh Hatshepsut expedition to Punt, Pharaoh Ramses III's naval battle, Hatshepsut marines in Deir el-Bahri, Syrian ships from tomb at Thebes, Old Kingdom travelling ship from tomb of Nikanesut, sailing vessel from the tomb of Rekhmire and practicing fighting skills on papyrus boats [2].

Couser, Ward and Vosmer (2009) in their paper about the hypothetical reconstruction of an ancient Egyptian seagoing vessel from the reign of Hatshepsut presented reliefs in Der el- Bahri for Pharaoh Hatshepsut ships. They travelled with the constructed ship in the Red Sea from Egypt to Sudan cutting 120 miles journey [3]. Ward, Couser, Vann and Abdel-Mauguid (2009) outlined that discoveries at Wadi Gawasis and Ayn Sukhna on the Red Sea provided the first evidence of an Egyptian seagoing ships. They designed and constructed a seagoing ship following the ancient Egyptian designs having 20.3 m overall length [4].

Holmes (2010) in his book about ancient and modern ships presented scenes for ancient Egyptian boat from the 3rd Dynasty, 4th Dynasty, Nile barge from 1600 BC and battleship from the 20th Dynasty [5]. Creasman (2010) in his Ph. D. Thesis presented a photo for woodworking tools from Thebes (1300 BC) in the British Museum, a scene for ship construction from the Egyptian Middle Kingdom and a carpentry shop model from the 11th Dynasty [6].

Ward (2012) in her paper about building Pharaoh's ships presented a wall relief of seagoing ships in the temple of Pharaoh Hatshepsut at Deir el- Bahri. She presented also a photo for a Min of the Desert ship of 20 m length built as a reconstruction of an ancient Egyptian seagoing ship of Pharaoh Hatshepsut of the 18th Dynasty [7]. Belov (2014) in his study about new evidence for the steering system of the Egyptian Baris presented scenes for sailed and un-sailed boats from reliefs in Deir el-Gabrawi from the 6th Dynasty, boat scenes from the 12th Dynasty, 20th Dynasty and 25th Dynasty [8].

Hassaan (2016) in his study of mechanical engineering in ancient Egypt through investigating the models industry presented boat models from Naqada II, Naqada III, 6th Dynasty, 9th -10th Dynasties,11th and 12th Dynasties and warship model from the 20th Dynasty [9]. Belov (2017) in his paper about ancient Egyptian ships graveyard from Heracleion pointed out that 60 ancient Egyptian ships were found on the site of Thonis-Heracleion from the Late and Ptolemaic Periods. The found ships, as he claimed, belonged to the baris-type as described by Herodotus 2.96 [10]. Wikipedia (2018) wrote an article about the military of ancient Egypt and presented a model of a warship fleet belonging to Pharaoh Ramses III of the 20th Dynasty. They pointed out that the Egyptian troops were transported by naval vessels as early as Late Old Kingdom [11,12].

Belov (2019) in his paper about loose-footed sails on the Egyptian New Kingdom ships pointed out that ancient Egypt was the origin of loose-footed sails and presented evidences for this from the 18th, 19th and 20th Dynasties [13]. Hassaan (2019) investigated the boats industry in ancient Egypt during the Predynastic to Middle Kingdom Periods [14] and during the New Kingdom and Late Periods [15]. He presented models and scenes identifying the types, designs and characteristics of boats produced by ancient Egyptians for various purposes.

II. SHIPMAKING IN ANCIENT EGYPT

Great civilizations comprise strong economy and fruitful relations with neighbouring states. Reflecting this to Egypt we find that it is surrounded by three continents. To deal with other nations in the three continents required having large naval that can sail in the Red Sea and in the Mediterranean Sea. They used the acacia timber for boats and warships building since the Predynastic Period (prior to 3200 BC) and used cedar imported from Lebanon starting also from the Predynastic times [16]. In the 12th Dynasty, the Egyptian carpenters produced cedar-veneer of thickness between 1.5 to 2.5 mm [16] and the mid-4th millennium BC, they produced wood-planks of up to 2 m length and 20 mm thickness [7]. This of course helped them to build the hull and cabinets of their ships.

.

III. EARLY DYNASTIC SHIP PRODUCTION

The ancient Egyptians started building trading ships since the time of Naqada I (4000 BC) [17]. . Since the 1st Dynasty, the ancient Egyptians started authorizing using ships through tomb reliefs. Fig.1 shows a ship relief from the tomb of Den, the 5th King of the 1st Dynasty (2990-2940 BC) [18]. The ship was powered by a trapezoidal sail with a sailor looking after it and two helmsmen looking after the two steering oars of the ship at its stern. The ship pilot was shown standing on a horizontal panel above the ship-stern. Other crew-sailors on the deck at the middle were shown busy in deeds related to the ship navigation.

Fig.1 Ship relief from the 1st Dynasty [18].

IV. OLD KINGDOM SHIP PRODUCTION

The ancient Egyptians paid great effort in the development of ships during the Old Kingdom and registered this effort in different forms as will be depicted through the following examples from the 4th and 5th Dynasties:

- The first example is a ship scene from the tomb of Prince Merab (probably the son of Khufu), the 2nd King of the 4th Dynasty (2589-2566 BC) and shown in Fig.6 [18]. The ship was powered by a sail and 16 rowing sailors. It was steered by 3

helmsmen, sail set by one sailor, directed by a pilot and his assistant with goods or passenger cabinet on the deck.

Fig.2 Ship scene from Merab Tomb from the 4th Dynasty [18].

- The second example is a travelling ship scene from the tomb of Nikanesut, an Official during the 5th Dynasty of the Old Kingdom (2494-2345 BC) shown in Fig.3 [19]. The ship was powered by a trapezoidal sail controlled by a number of robes connected to the deck in three locations. Its steering was applied using three oars near its stern. The sail position was set by two sailors, one near the row and one near the stern. There was a passenger cabinet on the deck. The ship had a pilot standing in front of the cabinet and watching the sea and an assistant on the roof of the cabinet giving navigation orders.

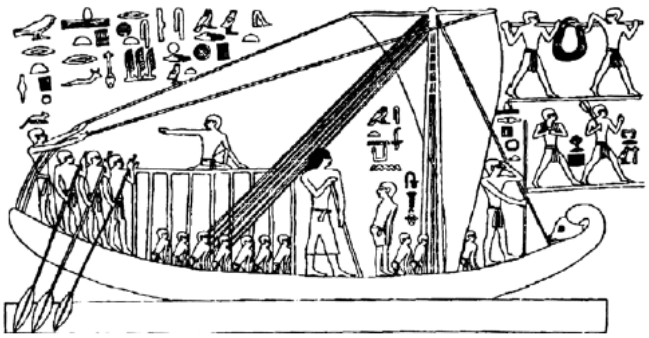

Fig.3 Ship scene from Nikanesut Tomb from the 5th Dynasty [19].

- The third example is a ship scene from the 5th Dynasty (2494-2345 BC) shown in Fig.4 [20]. The ship was sailed using a rectangular red sail hinged to a mast and controlled by a large number of robes secured to the deck near its stern. Its direction was controlled by 3 steering oars hinged to a dike on the deck restricting their stroke.

Fig.4 Ship scene from the 5th Dynasty [20].

- The fourth example is a relief from the temple of Sahure, the 2nd King of the 5th Dynasty (2487-2475 BC) presenting one of his navy vessels carved in his Temple at Abu Sir and used in a battles in Asia and shown in Fig.5 [21]. The sail was shown set down, the ship was powered by a number of oars and its direction was controlled by 3 steering oars (only the right ones shown).

Fig.5 Ship relief from Sahure's temple of the 5th Dynasty [21].

- The fifth example is a drawing of a warship of King Sahure of the 5th Dynasty drawn by referring to the ship reliefs in his pyramid at Abu Sir and shown in Fig.6 [22]. The sail was set down, 14 powering oars (7 from each side) were raise up and 3 steering oars were raised up (may be in a break time). The ship was shown full of Asian captives following of the ancient Egyptian battles against their enemies at Asia.

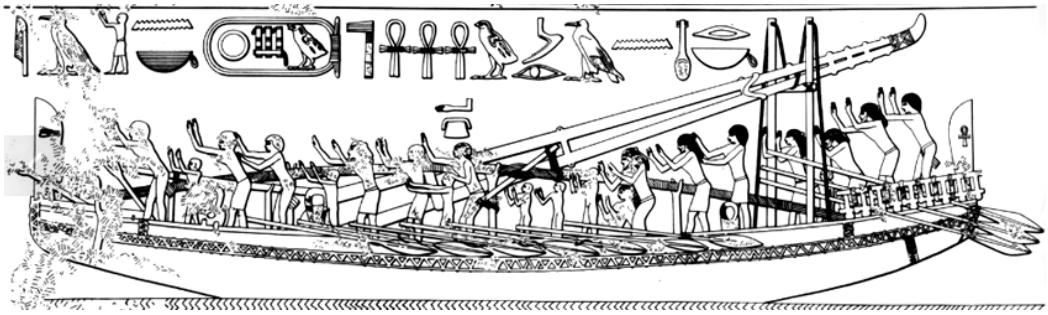

Fig.6 Ship drawing from Sahure's pyramid of the 5th Dynasty [22].

- The sixth example is a ship relief from the mastaba of Ti at Saqqara, overseer of the Pyramids of Nyuserre, the 6th King of the 5th Dynasty (2445-2421 BC) and shown in Fig.7 [18]. This ship relief-model was powered by sail and oars. The sail direction was controlled by a number of robes secured to the deck near the ship bow and one sailor was shown setting the sail. About 28 oars were used 12 from each side were used to row the ship. Three helmsmen were shown controlling the direction of the ship using long oars joined to the deck near its bow. The pilot was shown sitting on a cabinet before the helmsmen.
- The seventh example is a ship relief from the mastaba of Ti at Saqqara, overseer of the Pyramids of Nyuserre, the 6th King of the 5th Dynasty (2445-2421 BC) and shown in Fig.8 [18]. This ship relief-model was similar to than in Fig.7 except the number of helmsmen steering the ship. Here, they are four and the sail direction sailor was shown sitting over a cabinet and holding a number of robes in both hands.

Fig.7 Ship relief from Ti's mastaba from the 5th Dynasty with 3 helmsmen [18].

Fig.8 Ship relief from Ti's mastaba from the 5th Dynasty with 4 helmsmen [18].

V. NEW KINGDOM SHIP PRODUCTION

The New Kingdom was the strongest and powerful period during the ancient history of Egypt. They build a wide empire extending in three continents. This empire comprised the Red Sea and the Mediterranean Sea. Therefore they were in need to build seagoing ships capable to connect the three continents. This will be depicted by the following examples of ships build during the New Kingdom:

- The first example is a 22 m length and 5 m width seagoing vessel from the 18th Dynasty (1580-1350 BC) built based on the ship scenes in Hatshepsut's Temple at Deir el-Bahri in display in the Marine's Museum at Virginia shown in Fig.9 [23]. The ship was powered by a 15 m height rectangular sail and 30 oars (15 from each side). Its direction was controlled by two steering oars near its stern. The stern was decorated by a carved wooden lotus flower.

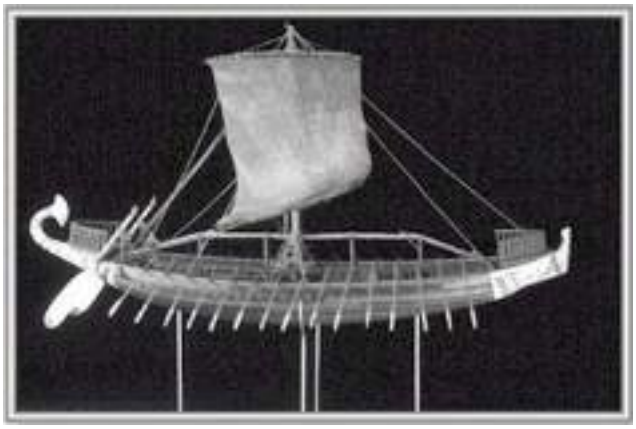

Fig.9 Ship model from the 18th Dynasty [23].

- The second example is the trade ships of Pharaoh Hatshepsut from the 18th Dynasty (1479-1458 BC) in display in her temple at Deir el-Bahri and shown in Fig.10 [24]. The scene depicted two ships in an expedition to Punt lands (Somalia) in a loading position. The ships were powered by sails controlled by a large number of ropes and steered by two steering oars near its bow.
- The third example is a scene for the Royal ship of Pharaoh Tutankhamun from the 18th Dynasty (1332-1323 BC) shown in Fig.10 [25]. The ship was powered by a semi-rectangular sail and its direction was controlled by two steering oars near its stern. It had a long cabinet at the middle of the deck and small cabinets near its bow and stern.

Fig.10 Hatshepsut's ship scene from the 18th Dynasty [24].

Fig.11 Tutankhamun's ship scene from the 18th Dynasty [25].

- The fourth example is a ship scene from the tomb of Huy, the Viceroy of Nubia under the reign of Pharaoh Tutankhamun of the 18th Dynasty (1353-1327 BC) shown in Fig.12 [26]. The ship was powered by a semi-rectangular sail with full crew and a number of oars from both sides of the deck. It was loaded by three cabinets, one large cabinet in the middle and two smaller cabinets near the row and stern of the ship.

Fig.12 Huy's ship scene from the 18th Dynasty [26].

- The fifth example is a ship scene from the tomb of Khaemwaset , the 4th son of Pharaoh Ramses II of the 19th Dynasty (died 1303 BC) shown in Fig.13 [27]. The colored scene in the Prince's tomb depicts a ship powered by a sail and had a large storage cabinet storing wine jars. It had two other small cabinets at its bow and stern with a carved lotus flower decorating its stern. The scene depicts also a steering oar hinged to a vertical pole near the stern end of the ship.

Fig.13 Khaemwaset's ship scene from the 19th Dynasty [27].

- The sixth example is a warship colored scene from the 19th Dynasty (1200 BC) shown in Fig.14 [28]. The ship depicted by the scene was powered by dual navigation system using a rectangular sail and 20 oars 10 from each side. Its bow was decorated by a carved animal and it had small cabinets at its bow and stern while steered by one steering oar joined to a vertical pole.

Fig.14 Ship scene from the 19th Dynasty [28].

- The seventh example is a relief for one of the battles of Pharaoh Ramses III of the 20th Dynasty (1186-1155 BC) against the see people in display in his temple in Medinet Habu shown in Fig.15 [29]. The war ships were navigated by sails and oars as depicted by the relief.

Fig.15 Warships scene from the 20th Dynasty [29].

VI. LATE PERIOD SHIP PRODUCTION

We have only two examples from the Late Period of the ancient Egyptian history presented as follows:

- The first example is a ship relief from the tomb of Vizier Nespekashuty from the 26th Dynasty (664-610 BC) in display in the Brooklyn Museum at New York and shown in Fig.16 [30]. The relief depicted the ship powered by sail and 12 oars 6 from each side. The sail was operated by a crew of 4 sailors shown ready for work.

Fig.16 Ship relief from the 26th Dynasty [30].

- The second example is the seagoing ships of Necho II, the 2nd Pharaoh of the 26th Dynasty (610-595 BC) who built ships to go through the Red and

Mediterranean Seas. The Greek Historian Herodotus outlined that the expeditions of Necho II went from Egypt through the Red Sea around Africa for the first time in 600 BC and discovered that the world is not flat [31].

VII. CONCLUSIONS

- The paper investigated the evolution of Mechanical Engineering in ancient Egypt through the production of seagoing ships.
- The study covered the historical era from Predynastic to Late Period.
- The ancient Egyptians started building ships since the time of Naqada I (6000 years ago).
- They authorized using sails and oars in powering their ships since the time of the 1st Dynasty (about 5000 years ago).
- They designed trapezoidal sales controlled by a large number of robes during the 1st Dynasty.
- During the Old Kingdom, they designed ships with trapezoidal and rectangular sails steered by two to four steering oars.
- Before the New Kingdom, they used paddling oars to help in ship navigation with up to 28 oars.
- Sails of the New Kingdom had height up to 15 m and they used up to 30 paddling oars.
- The left tomb scenes and temple reliefs for their seagoing ships with too many details that helped the scientists to extract the characteristics of the ancient Egyptian ships.
- They left colored scenes for some of their ships during the 19th Dynasty having colored sail and oars.
- They registered using warships in the battles against the Sea People during the 20th Dynasty.
- The same tradition of ship navigation continued through the Late Period of ancient Egypt.
- The ancient Egyptians succeeded to sail around Africa for the first time during the reign of Pharaoh Necho II of the 26th Dynasty using seagoing ships.

REFERENCES

1. *A. Silva, Shipbuilding during the ancient Mediterranean, Estrat Critic, vol.1, pp.33-43, 2007.*
2. *G. Gilbert, Ancient Egyptian sea power and the origin of maritime forces, Commonwealth of Australia, 2008.*
3. *P. Couser, C. Ward and T. Vosmer, Hypothetical reconstruction of an Egyptian seagoing vessel from the reign of Hatshepsut, 1500 BC, in Historical ships, The Royal Institute of Naval Architects, 19-20 November, 2009, London.*
4. *C. Ward, P. Couser, D. Vann, T. Vosmer and M. Abdel-Mauguid, Reconstruction and sailing performance of an ancient Egyptian ship, Proceedings of the 12th Symposium on boat and ship archaeology, Istanbul, Paper 39, 6 pages, 2009.*
5. *G. Holmes, Ancient and modern ships, eBook 33098, July 2010.*
6. *P. Creasman, Extracting cultured information from ship timber, Ph.D. Thesis, Texas A & M University, December 2010.*
7. *C. Ward, Building Pharaoh's ships: Cedar, incense and sailing the Great Green, British Museum Studies in Ancient Egypt and Sudan, vol.18, pp.217-232, 2012.*
8. *A. Belov, New evidence for the steering system of the Egyptian Baris/Herodotus 2.96, The International Journal of Nautical Archaeology, vol.43, issue 1, pp.3-9, 2014.*
9. *G. A. Hassaan, Mechanical engineering in ancient Egypt, Part XXV: Model industry (boats, ploughing, grain grinding, bakery and brewery), International Journal of Engineering and Techniques, vol.2, issue 5, pp.9-21, 2016.*
10. *A. Belov, Ancient Egyptian ships graveyard from Heracleion, Egypt and NeighbouringCountries, vol.1, pp.1-23, 2017.*
11. *Wikipedia, Military of ancient Egypt,* https://en.wikipedia.org/wiki/Military_of_ancient_Egypt, *2018.*
12. *J. Darnell and C. Menassa, Tutankhamun armies, J. Wiley and Sons, p.65, 2007.*
13. *A. Bebov, Loose-footed sails on the Egyptian New Kingdom ships, The International Journal of Nautical Archeology, vol.48, issue 1, pp.77-84, 2019.*
14. *G. A. Hassaan, Mechanical Engineering in ancient Egypt, Part 81: Boats industry during the Predynastic to Middle Kingdom, World Journal of Engineering Research and Technology, vol.5, issue 2, pp.103-132, 2019.*
15. *G. A. Hassaan, Mechanical Engineering in ancient Egypt, Part 82: Boats industry during the New Kingdom and Late Period, International Journal of Emerging EngineeringResearch and Technology,vol.7, issue 3, 2019 (Accepted for Publication).*
16. *D. Dixon, Timber in ancient egypt, The Commonwealth Forestry Review, vol.53, issue 3, pp.205-209 , 1974.*
17. *Turbosquid, 3D model of the ancient Egyptian merchant ship, period of Naqada II,* https://www.turbosquid.com/3d-models/3d-ancient-egyptian-merchant-ship-model-1247051

18. *Runasimi, Observations from Egyptian tombs and pyramids,* http://www.runasimi.net/farao-UK.htm , *2018.*
19. *G. Gilbert,2008, p.75.*
20. *Armament, Egyptian merchant ship,* http://armament-history.blogspot.com/2008/11/egyptian-merchant-ship.html , 2008.
21. *D. Korol, Rhe Royal fleet of King Sahur, AbuSir,* https://www.pinterest.com/pin/491877590526487716/?lp=true
22. *Britannica, Sahure, King of Egypt,* https://www.britannica.com/biography/Sahure , *2019.*
23. *Art Sales, Egyptian seagoing vessel XVIII Dynasty,* http://www.artsales.com/ARTistory/Ancient_Ships/06_egyptian_galleons.html , *2010.*
24. *Alamy, Transportation expedition to Punt, ships are loaded, https://www.alamy.com/stock-photo-geographytravel-egypt-transporttransportation-expedition-to-punt-ships-19375616.html , 2019.*
25. *History Museum, Transportation,* https://www.historymuseum.ca/cmc/exhibitions/civil/egypt/egcl04e.html
26. *Alamy, The Viceroy boat, tomb of Huy, https://www.alamy.com/stock-image-the-viceroys-boat-tomb-of-huy-charles-k-wilkinson-ca-1926-1927-ca-162558928.html , 2019.*
27. *Getty Images, Mural painting depicting scene of carriage of wine on a boat, https://www.gettyimages.co.nz/detail/news-photo/egypt-luxor-ancient-thebes-tomb-of-khaemwaset-mural-news-photo/122339600 https://www.gettyimages.co.nz/detail/news-photo/egypt-luxor-ancient-thebes-tomb-of-khaemwaset-mural-news-photo/122339600, 2010.*
28. *Cogand Galley, Ancient Egyptian navy,* http://www.cogandgalley.com/2009/03/ancient-egyptian-navy.html , *2009.*
29. *H. Nelson, The naval battle pictured at Medinet Habu, Journal of Near Eastern Studies, vol.2, issue 1, pp.40-55, 1943.*
30. *Commons Wikimedia, WLA Brooklyn Museum relief blocks from the tomb of Nespeqashut, https://commons.wikimedia.org/wiki/File:WLA_brooklyn_museum_Relief_Blocks_from_the_Tomb_of_Nespeqashut_2.jpg , 2018.*
31. *Ancient Origins, When sailors from ancient Egypt discovered the world is not flat,* https://www.ancient-origins.net/history-important-events/world-not-flat-0010733 , *2018.*

DEDICATION

I dedicate this work to Engineer Chris Dunn, the outstanding Egyptologist and one of the true lovers of ancient Egypt and its civilization. This is because I knew Mr. Dunn through his works as articles or valuable books on the ancient Egyptian technology. I wish all the best for a great engineer like him and I had the honour to meet him in Luxor on 12th March 2019. Welcomed in Egypt dear friend.

BIOGRAPHY

Galal Ali Hassaan

- Emeritus Professor of System Dynamics and Automatic Control.
- Has got his B.Sc. and M.Sc. from Cairo University in 1970 and 1974.
- Has got his Ph.D. in 1979 from Bradford University, UK under the supervision of Late Prof. John Parnaby.
- Now with the Faculty of Engineering, Cairo University, EGYPT.
- Research on Automatic Control, Mechanical Vibrations , Mechanism Synthesis and History of Mechanical Engineering.
- Published more than 255 research papers in international journals and conferences.
- Author of books on Experimental Systems Control, Experimental Vibrations and Evolution of Mechanical Engineering.
- Chief Justice of the International Journal of Computer Techniques.
- Member of the Editorial Board of some international journals including IJET.
- Reviewer in some international journals.