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Mechanical Engineering in Ancient Egypt, Part 91: Cisterns Management

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

Abstract:

The ancient Egyptians succeeded to use the River Nile in an optimal way to get maximum benefit from its sweet water. They designed, produced and used portable cisterns to store water for domestic uses. The paper outlines the development of portable cisterns over an era from the Predynastic to the Ptolemaic Periods. It presents the effort of the ancient Egyptians to construct underground cisterns during the Second Intermediate, New Kingdom and Third Intermediate Periods. It highlights the possibility of using modern depressions and lakes to store sweet water up to 1412 km^3 which is big enough for the Egyptian demand of sweet water and opens the door for water exportation to neighbor countries.

Keywords — **Mechanical Engineering history, Cistern management, Portable cisterns, Underground cisterns.**

I. INTRODUCTION

Ancient Egyptians new that rain is limited in Egypt. Therefore, they relied mainly on the River Nile and constructing wells as a secondary source for water. Even though, they did not neglect the construction of cisterns in the Egyptian deserts to collect rain water and help travellers in the desert roads to find sweat water for their selves and for their animals.

Murray (1955) in his book about some ancient Egyptian achievements regarding water from the desert outlined that He knows two cisterns in Northern Sinai. One of them at Darb el-Hagg and the second at the angle formed by the two roads to El-Arish from Hasana and Qusaima. He also outlined that there are about 3000 cisterns between Alexandria and Sallum in the West of Egypt. He presented a photo for one of the cisterns in the Western Desert [1]. Bazza (2006) in his paper about the history of water resources and irrigation management in the Near East Region outlined that cisterns were used in North Africa where they were filled by rainwater drained from mountains. They had very important storage capacity (as he stated) [2].

Franzmeier (2008) in his work about wells and cisterns in Pharaonic Egypt discussed the cisterns in the ways of Horus in Northern Sinai. Besides, he mentioned the cisterns founded during the Amarna Period during the time of Pharaoh Seti I of the 19th Dynasty which was as large as 20 x 20 m in Deir el-Balah and Deir el_Abd. Also, another post-Amarna stone-lined cistern at Tell el-Borg was mentioned [3]. Bader (2009) presented the designs of of clay vessels from First Intermediate Period, Early Middle Kingdom at Herakleopolis Magna and from Late Old Kingdom/Early First Intermediate Period giving the shape and some of the dimensions and material [4].

Mays, Antonian and Angelakis (2013) in their paper about history of water cisterns outlined that cisterns range from clay pots to large underground structures. They did not handle the development of cisterns in ancient Egypt [5]. Othman (2017) in his paper about cisterns, wells and use of water in the mining and quarrying sites of the Eastern Desert of Egypt mentioned three cisterns of 6x39 m, 4.8x3.85 m and 4.5x3.55 m dimensions. Besides, he presented the cistern of Krokodilo with wall and bottom covered with fine white lime having the dimensions: basin of 7.4x8.5 m cross-section and 3.35 m depth. He presented a photo for the Krokodilo cistern constructed during 110-115 AC [6].

Dunn (2020) in an article about the cisterns of Alexandria announced that the most amazing

discoveries beneath the streets of Alexandria is that of the city's ancient system of cisterns. Furthermore, he said that the water for houses and buildings was drawn from the cisterns with aid of saqiehs (waterwheels) [7]. Darnell (2020) in his article about Tundaba cistern stated that the cistern was a collection point and a holding tank of rainwater entering the Tundaba depression from surrounding wadies. Besides he provided photos for the cistern and said that its roughly circular upper portion had about 7 m diameter and 4.5 m depth with total depth of the cistern of about 28 m [8].

II. PORTABLE CISTERNS

The ancient Egyptians were pioneers in the design and production of pottery jars of numerous sizes and used them for water storage since the time of the Predynastic Period. Tis continued through all their Pharaonic ages as will be depicted by the following examples:

- The first example is a pottery water jar from the time of Naqada II, 3650-3300 BC in display in the Museum of Fine Arts at Boston and shown in Fig.1. It was decorated by boat and plant elements and has the dimensions: 191 mm height and 158 mm maximum diameter [9].

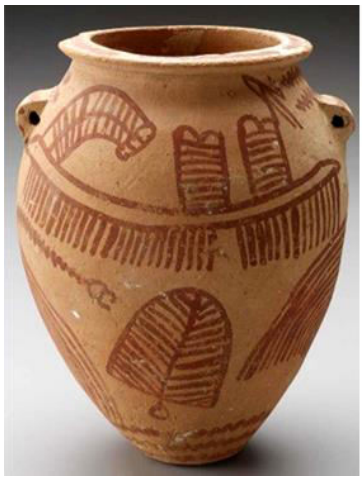

Fig.1 Decorated water jar from Naqada II [9].

- The second example is a pottery cylindrical jar from the 1st Dynastic, 3100-2649 BC in display in the Metropolitan Museum of Art and shown in Fig.2. It has no decorations, a flat base, 259 mm height and 114 mm diameter [10].

Fig.2 Water jar from the 1st Dynasty [10].

- The third example is a large pottery jar from the 2nd/3rd Dynasties, 2649-2100 BC in display in the Metropolitan Museum of Art and shown in Fig.3 [11]. It is not decorated, has a point-base and its dimensions are not available.

Fig.3 Water jar from the 2nd/3rd Dynasties [11].

- The forth example is a large pottery water jar from the Middle Kingdom, 2030-1640 BC, in display in the Metropolitan Museum of Art and shown in Fig. 4. It has a medium neck, point-base and a 462 mm height [12].
- The fifth example is a pottery water jar from the New Kingdom in display in the Antiquities Museum Bibliotheca Alexandrina

and shown in Fig.5 and having a 540 mm height [13]. It has a small base and decorated by bounded bale-blue bands on most of its outside surface.

Fig.4 Water jar from the Middle Kingdom [12].

Fig.5 Water jar from the New Kingdom [13].

- The sixth example is a blue painted pottery storage jar from the 18th Dynasty, reign of Pharaoh Akhenaten, 1352-1336 BC, in display in the Metropolitan Museum of Art, shown in Fig.6 and has a 456 mm height [14]. It has a point-base, decorated by blue bands on its top-half surface.
- The seventh example is a large water storage pottery jar from the Ptolemaic Period, 3rd-2nd Century BC, in display in the Metropolitan Museum of Art, shown in Fig.7 and has 620 mm height and 480 mm maximum diameter [15]. It is decorated by dark-blue floral images between bands on its top surface and two parallel circular bands on the bottom surface.

Fig.6 Water jar from the 18th Dynasty [14].

Fig.7 Water jar from the Ptolemaic Period [15].

III. CISTERN MANAGEMENT DURING THESECOND INTERMEDIATE / NEW KINGDOM PERIODS

The Second Intermediate Period extends from 1650 to 1550 BC while the New Kingdom extends from 1550 to 1077 BC [16], [17]. The ancient Egyptians developed and managed desert cisterns during this period as depicted in the following example:

- They constructed a cistern in Tundaba (location in the Western Desert of Egypt at a midpoint of the main Northern route between

the Nile and the North-Eastern wells of Kharga Oases [18]).

- The Tundaba cistern was constructed during the 17th/18th Dynasties to collect rainwater in Tundaba depression from surrounding areas. Fig.8 shows the design of the cistern [19,20].

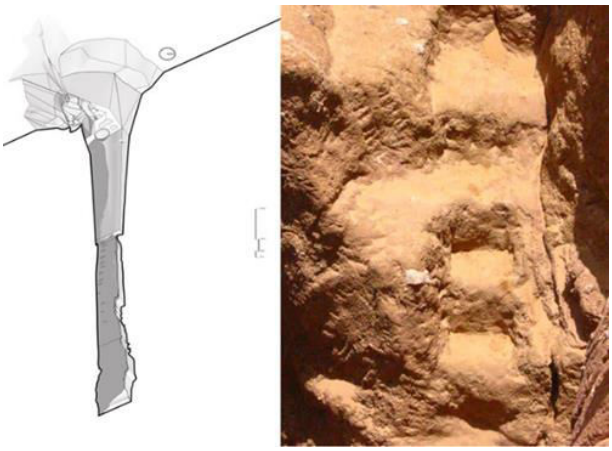

Fig. 8 Tundaba cistern design [19, 20].

- The upper part of the cistern has 7 m maximum diameter while the bottom part has 4.5 m maximum diameter [19].
- The overall depth of the cistern is about 28 m [20].
- To reach the water level in the cistern, they managed a stairs-system from the top surface to the water level as shown in Fig.8.

IV. CISTERN MANAGEMENT DURING THE THIRD INTERMEDIATE PERIOD

- The Pharaohs of the 21st Dynasty and Early 22nd Dynasty constructed huge impressive cisterns in the Temple of Amun at Tanis [21].
- The first example of those cisterns is a circular cistern shown in Fig.9 [21]. It has the features:

- Dimensions are not given.
- It is in a depression of desert.
- The ancient Egyptians digged a rectangular channel of increasing depth to help in collecting and guiding rainwater to the cistern.
- The cistern is lined by stone to minimize water leakage through the cistern walls.
- To measure the water level inside the cistern, they connected it to a nilometer (not shown in Fig.9). This is really a clever feature from the ancient Egyptians to evaluate the experiment of using cisterns in Egypt to get use of the rainwater !.

Fig. 9 Temple of Amun circular cistern at Tanis [21].

- The second example is a rectangular in the Temple of Amun at Tanis shown in Fig.10 [21].

Fig. 10 Temple of Amun rectangular cistern at Tanis [21].

- It has the features:

- Dimensions are not given.
- The cistern is lined by stone to minimize water leakage through the cistern walls.
- The carved stairs from one side to help the users to reach the water level inside the cistern.

V. FUTURE CISTERN MANAGEMENT

- Egypt does not have heavy rain falls.

- Some resources estimate the quantity of rain fall in Egypt as 1.3 km^3/year [22].
- Others give this estimation as 1.8 km^3/year [23].
- However, the change of weather in the last years resulted in heavy rainfalls on Egypt resulted in floods and high level of water in the streets reaching about 80 cm as depicted from Fig.11 [24].

Fig. 11 Rainfall water in Cairo streets in 2018 [24].

- This high level of rainfall water in Egypt gives an estimate of 4 km^3/year based on a surface area of 1000 km^2 and a frequency of heavy rain occurrence of 5 per year.
- Egypt is in need to 90 km^3/year of sweet water for agriculture and drinking needs [25].
- The question rising now is: Does Egypt has enough basins (cisterns) to contain and store sweet waters from different sources to compensate the expected reduction of River Nile water after the construction of the '*Renaissance Dam*' at Ethiopia ?.
- Egypt has a number of natural and artificial basins (cisterns) of different capacities. Here are some of them:

- Qattara Depression: It is a natural depression having the characteristics [26]:
  # Surface area: 19,605 km^2 if filled to sea level.
  # Maximum depth: 147 m below sea level.
  # Volume: 1,213 km^3.
  # Map: shown in Fig.12.
- Lake Nasser: It is an artificial depression having the characteristics [27]:
  # Surface area: 5,250 km^2.
  # Maximum depth: 130 m below sea level.
  # Volume: 132 km^3.
  # Map: shown in Fig.13 [28].

Fig. 12 Qattara Depression location [25].

Fig. 13 Lake Nasser location [28].

- Toshka Lakes: It is an artificial depressions having the characteristics [29]:
  # They are four deep-cut basins.
  # Surface area: 384.7-1259.8 km^2.
  # Maximum depth: 100-125 m.
  # Volume: 4.93-38 km^3.
  # Total volume: 66.1 km^3.
  # Map: shown in Figs.13 and 14.

Fig. 14 Four Toshka Lakes [29].

- Lake Qarun: It is an artificial depression having the characteristics [29]:
  # Surface area: 240 km^2.
  # Maximum depth: Over 8 m.
  # Volume: 0.80 km^3.
  # Annual drainage water reaching the lake: 0.37 km^3.
  # Map: shown in Fig.13 [30].

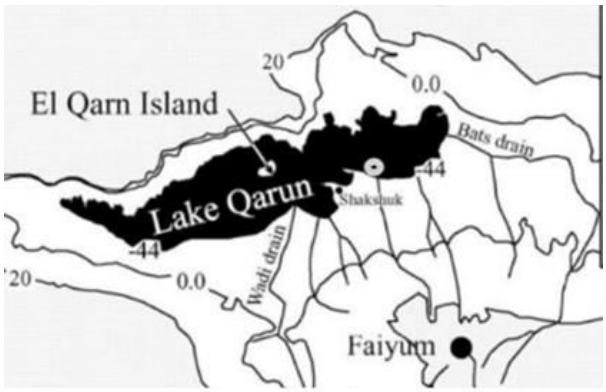

Fig. 15 Lake Qarun location [30].

VI. CONCLUSION

- The development of Mechanical Engineering in ancient Egypt was studied through the cistern management in ancient Egypt.
- Any nation needs sweet water to stay alive.
- Because the River Nile runs through Egypt, the ancient Egyptians used portable cisterns since the Predynastic era in the form of '*Pottery jars*'. They continued to use them till their recent days.
- The present work presented samples of the portable cisterns from the time of Naqada II, 1st Dynasty, 2nd/3rd Dynasties, Middle Kingdom, New Kingdom and Ptolemaic Period.
- The samples presented varied in capacity, shape and decoration.
- The ancient Egyptians digged underground cisterns to facilitate storage of sweet water for various purposes.
- They constructed the '*Tundaba cistern*' during the 17th/18th Dynasties to collect water from the '*Tundaba Depression*' having 28 m depth and diameter up to 7 m.
- The Pharaohs of the 21st and 22nd Dynasties constructed a huge cistern in the Temple of Amun at Tanis. It was lined by stone to minimize water leakage through its wall and equipped with a '*nilometer*' to measure its water level.
- They planned carved stairs going down the cistern from its mouth to allow transferring the water safely by '*porters*'.
- Egypt may have a shortage of sweet water in future because of the construction of the '*Renaissance Dam*' at Ethiopia.
- The paper studied the availability of a great depression and a number of lakes that can store a huge amount of sweet water with maps of their location in Egypt.
- Those depression and lakes can store up to 1412 km^3 of sweet water helping in solving Egypt's sweet water shortage from the River Nile. This may also open the door for Egypt to export sweet water to its neighbour countries such as Libya, Palestine and Jordon.

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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 265 research papers in international journals and conferences.

- Author of books on Experimental Systems Control, Experimental Vibrations and Evolution of Mechanical Engineering.
- Chief Editor of the International Journal of Computer Techniques and International Journal of Engineering and Techniques.
- Member of the Editorial Board of some international journals.
- Reviewer in some international journals.