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MECHANICAL ENGINEERING IN ANCIENT EGYPT, PART XVI: GLASS INDUSTRY (MIDDLE AND NEW KINGDOMS)

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ABSTRACT

This is the 16th research paper exploring the development of Mechanical Engineering in Ancient Egypt. The paper investigates the production of glass vessels in ancient Egypt during the Middle and New Kingdoms presenting and analyzing samples of this production. It traces the materials used in global, the units of each vessel and its decoration in details. It concentrates on exploring the beauty, excellence and innovation of design, production and decoration. It highlights the ancient Egyptian dynasty that could master the glass vessels production and could provide the highest technology in production and decoration.

KEYWORDS: History of mechanical engineering, ancient Egypt , glass industry, Middle Kingdom, New Kingdom.

INTRODUCTION

Glass vessels are one of the advanced and sophisticated industries practiced by ancient Egyptians. They could produce glass vessels starting from the Middle Kingdom that had outstanding and difficult design and decorated by various scenes of muti-colors and covering the whole vessel.

Mc Govern, Fleming and Swann, 1993 outlined that the Egyptians appear to have controlled the silicate industry including the preparation and supply of raw materials and glass and faience vessels imported to Palestine from Egypt.[1] Lilyquist and Brill, 1996 announced that

they discovered that the Metropolitan Museum objects from the tomb of the three wives of Thutmose III in the Wadi Al-Qirud at Luxor had a glass lotiform vessel and two other glass vessels. They started a collaborative project at the Metropolitan Museum of Art and the Coring Museum of Glass to build a corpus of early dated glasses.[2] Rehren, 2000 demonstrated that possible two independent melting temperature indicators were correlated, suggesting a factual relationship between melting temperature and melt composition. He used this evidence to develop a 'partial batch melting model'.[3] Grossmann, 2002 showed that through pieces in the Yale collection, it was possible to nearly, the full range of technological, stylistic and functional development in the history of glass from its early development in the Bronze Age into late antiquity.[4] Rehren, 2008 argued that there are strong and systematic shifts between plant ash composition and the resulting glass. His work aimed to explore the various factors to raise awareness of the issues involved and to stimulate further research.[5] Nicholson, 2011 outlined that glass in ancient Egypt appeared in the New Kingdom (!). He outlined the production techniques in ancient Egypt as forming the vessel around a friable core and the casting of glass in moulds to make solid objects.[6] Hunt, 2012 outlined that the fish was widely considered as a symbol of regeneration and reproductive strength. He presented a the decoration of the tilapia fish glass vessel used as a cosmetic bottle manufactured during the rein of Akhenaten of the 18th dynasty.[7]

Kikugawa, Abe, Nakamura and Nakai, 2014 applied non-destructive X-ray analyses to ancient Egyptian copper-red glass artefacts to investigate the colouring mechanism of the glass and relationship between colouring mechanism and chemical composition. They suggested that the colouring mechanism of copper-red glass changed from crystalline-CU2O colouring to metallic-Cu nano-cluster colouring in ancient Egypt glass production.[8] Klein, 2015 stated that glass was first created in Mesopotamia and ancient Egypt 4500 years ago. He outlined also that the glass core-forming process for bead-making was Egyptian and the metal blow pipe was Roman.[9] Bohstrom, 2016 declared that cobalt glass beads found in Scandinavia Bronze Age tombs reveal trade connections between Egyptians and Mesopotamia 3400 years ago. He said that the analysis showed that the blue beads buried with women in Denmark were originated from the same glass workshop in Amarna during the rein of King Tutankhamun.[10]

Medium Kingdom

The Medium Kingdom Period covers the 11st to the 12th dynasties over the time period from 2000 to 1700 BC.[11] There are few examples available for some glass vessels from this era displayed in Liverpool Museum of UK. Some of them are presented.

- Fig.1 shows a glass vessel manufactured from a dark blue glass and decorated by trails of yellow and pale blue with two handles one of them broken.[12] It has a medium mouth, round flaring rim, medium neck, ovoid body and small flat base.

Fig.1 Glass vessel from the Middle Kingdom.[12]

- The second model is a glass amphora with lid and two handles shown in Fig.2.[13] It is manufactured from a dark blue glass and decorated by wavy trails of yellow, green and pale blue colors over its body. It has a medium mouth, round flaring yellow rim, medium undecorated neck except one trail going around its bottom, two undecorated handles between the shoulder and middle of the neck, ovoid body and flat base. The lid has a round handle and fits exactly inside the rim.

Fig.2 Glass amphora from the Middle Kingdom.[13]

- Third model from the Medium Kingdom is a small amphora decorated fully on its outside surface, manufactured from dark blue and white glass and shown in Fig.3.[13] It has a medium mouth, round flaring rim, relatively long neck, ovoid body and medium flat base.

It has two large handles between its shoulders and the flaring rim. The whole surface is decorated by complex scenes including wavy trails.

Fig.3 Small glass amphora from the Middle Kingdom.[13]

- The fourth model is a glass handless vase shown in Fig.4.[14] It has a medium mouth, round flaring rim, concave long neck and ovoid body. The vase is manufactured from a yellow glass and decorated in dark-green feathers or plants and wavy trails.

Fig.4 Glass vase from the Middle Kingdom.[14]

- The last model from the Medium Kingdom is a glass jug with spout as shown in Fig.5.[15] It has a small mouth, rim integrated with a spout simulating a Hun head [zoomed in Fig.15 (b), short neck, ovoid body and a large single handle between the shoulder and rim. It is manufactured from dark blue glass and the top half of the body is decorated by wavy trails of yellow and pale blue colors. It seems that the handle has an elliptical cross-section with decreasing dimensions from its beginning at the shoulder to its end at the trim.

(a) Jug **(b) Spout**

Fig.5 Glass jug from the Middle Kingdom.[15]

New Kingdom

The New Kingdom Period covers the 18st to the 20th dynasties over the time period from 1570 to 1069 BC.[16] The production technology had a high standard level during the wealthy Egyptian 18th dynasty of the New Kingdom regarding the manufacturing of pottery vessels[17], stone vessels[18] and faience vessels.[19] Through our presentation of glass vessels design and production during the New Kingdom we will see how the ancient Egyptians were pioneers also in glass vessels manufacturing.

18th Dynasty

We start by models related to Pharaoh Thutmose III, the 6th Pharaoh of the 18th dynasty (1479-1425 BC), Pharaoh Amenhotep III, the 9th pharaoh of the 18th dynasty (1388-1350 BC) and Pharaoh Akhenaten, the 10th pharaoh of the same dynasty (1351-1334 BC).

- Fig.6 shows a glass chalice belongs to Pharaoh Thutmose III, the 6th Pharaoh of the 18th dynasty displayed in the Harrow School of London.[20] The chalice is manufactured from a pale-blue glass, has a round rim, conical body, parabolic transition to the base-neck and a flaring-flat-round base. It is decorated by wavy trails in yellow and dark-blue colours.

Fig.6 Glass chalice of Pharaoh Thutmose III. [20]

- Fig.7 shows a handless glass jar from the palace of Pharaoh Amenhotep III in Thebes.[20] It is manufactured from a dark blue glass and has a wide mouth, round flaring rim with V-notch acting as a spout, long neck, spherical body, conical base-neck and a flat flaring base. The whole external surface is decorated by complex scenes in white, pale blue and yellow colours.

Fig.7 Glass jug of Pharaoh Amentotep III.[21]

- Another model from the rein of Pharaoh Amenhotep III is a four-handled glass vessel Displayed in the Metropolitan Museum of Art at NY and shown in Fig.8.[22] This is one of the mysterious ancient Egyptians mechanical engineering technology indicating very high sophistication in Art and Engineering. One does not know how could the ancient Egyptians produce this amazing piece using the technology of 3350 years ago ?. I sent electronic mails to two professors in UK specialized in Glass Science and two glass factories in USA asking about the possibility of producing a prototype of those glass vessels nowadays. I am still waiting their reply. The vessel has a small mouth, round flaring rim, average neck, stretched ovoid body, small base-neck and a flaring round flat base. It has four dark-blue small handles at the vessel shoulder. The decoration is extensive and marvellous. It is manufactured from dark-blue glass, the rim is decorated by a red band with parallel inclined hatching in white. The neck is decorated by wavy trails in pale-blue, white and red colours. The body is decorated between two wide white-bands with wavy trails in pale-blue, white and red colours. The base rim is decorated by parallel inclined white hatching.

Fig.8 4-handled glass jug of Pharaoh Amentotep III.[22]

- Now we move to the rein of Pharaoh Akhenaten, the 10th Pharaoh of the 18th dynasty and present two glass vessels models. Fig.9 shows a 175 mm spindle glass bottle displayed in the Metropolitan Museum of Art.[23] It is manufactured from pale-blue, has a round flaring rim, medium mouth, ling cylindrical neck, stretched ovoid body, flaring flat base with round rim. It has a single large elliptical cross-sectional handle between the bottle shoulder and the end of the top fourth of the neck. The rim is in dark blue, the base is in white, the neck and body are fully decorated by wavy trails in dark-blue, white and pale-blue. The handle is decorated by straight trails in dark and pale-blue.

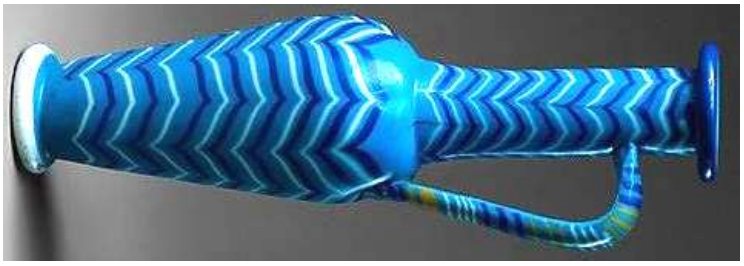

Fig.9 Spindle bottle from the rein of Akhenaten.[23]

- The second model from the rein of Pharaoh Akhenaten is a two-handled vessel displayed in the Metropolitan Museum of Art and shown in Fig.10.[24] It has a medium mouth, flaring round rim, medium neck, spherical body and a medium flat base. It has two 180 degrees medium handles between the vessel shoulder and middle of the neck. It is manufactured from a pale-blue glass. The rim is decorated by white inclined hatching, the neck is decorated by wavy trails in white, dark-blue and pale-blue. The body is decorated between two combination of dark-blue, yellow and white bands with feathers or plant stems (with leaves) in white, pale blue and dark-blue.

Fig.10 2 handled vessel from the rein of Akhenaten.[24]

Now, we leave the royal reins to models from the 18th dynasty, but not related to any of the Pharaohs of this dynasty.

- Fig.11 shows a handless-glass vessel from the 18th dynasty.[25] It is manufactured from dark blue glass. It has a medium mouth, round flaring flat rim, small neck rounded to an ovoid body, rounded to a small base neck, rounded to a round flaring flat base. The rim is decorated by a parallel inclined thick hatching lines, the neck is decorated by pale-blue wavy trails, the body is extensively decorated by wavy trails in yellow, dark-blue and pale blue in a very complex scene.

Fig.11 handless-vessel from the 18th dynasty.[25]

- The next model is a wonderful glass cosmetic vessel displayed in the British Museum and shown in Fig.12.[26] It simulates a River Nile Tilapia. It is manufactured from dark-blue glass. The fish head is decorated by an orange mouth and gills and white and black eyes. The body is decorated by peels of white, pale-blue and orange colors. The fins are decorated by yellow, orange and dark-blue trails. The tail is decorated by orange, yellow, white and dark-blue thick trails.

Fig.12 Fish-shape cosmetic vessel from the 18th dynasty.[26]

- Another model from the 18th dynasty is a glass vessel with two handles displayed in the Walters Art Museum at Baltimore, USA and shown in Fig.13.[27] It has a medium mouth, flaring round rim, medium cylindrical neck, dual-conical body with short shoulder, and medium flat base and two small handles at the middle of the vessel. It is manufactured from white glass and decorated at its rim, its neck and its top part of the body. The decorations are by wavy frails of brown, pale-blue, and white colors. The two handles are in dark-blue.

Fig.13: Glass vessel with 2 handles from the 18th dynasty.[27]

- The next model from the great 18th dynasty is a miniature glass vase of 60 mm height and 46 mm maximum diameter shown in Fig.14.[28] It has a wide mouth, round rim, long neck, ovoid body, short base-neck and flat flaring base. Most probably, it is manufactured from dark-blue glass. The rim is decorated by yellow parallel-inclined hatchings, the neck and body are decorated by wave trails in yellow, dark blue and pale-blue colors and the base had yellow and dark-blue trails. The base neck and most of the base are in pale blue. There is a dark-blue band on the body shoulder hatched by parallel curves. One can ask himself: how could those generous engineers and technicians design and produce all those details in only 60 mm glass object ?.

Fig.14: Miniature glass vase from the 18th dynasty.[28]

- Another model of glassware from the 18th dynasty is a glass vessel of wonderful decoration and coloring shown in Fig.15.[29] It is manufactured from a brown glass, has a medium mouth, round rim, long neck, ovoid body and a flaring flat base. It has a single handle between the neck and the shoulder of the vessel. The rim is decorated by white parallel-inclined hatching, the neck is decorated by wavy trails in yellow and white colors, the body is decorated by a pale-blue band on the top part of the body and wavy trails on the bottom 60 % of the body in yellow, white and brown colors. The base is decorated by an orange band.

Fig. 15: Glass vessel from the 18th dynasty.[29]

19th/ 20th Dynasties

As expected, the wealthy 18th dynasty had the major models of wonderful glass vessels. However, we still have some models from the 19th / 20th dynasties:

- Fig.16 shows a handless glass vase displayed in the Metropolitan Museum of Art.[30] It has a small mouth, flaring round rim, long neck, double parabolic body and a small flat base. It is manufactured from pale-blue glass and decorated only on its neck. The

decorations are zoomed in Fig.16 (b). It is decorated by scenes arranged in vertical columns including feathers in orange, dark-blue and pale-blue colours.

(a) Vase **(b) Zoomed neck**

Fig.16: Glass vase from the 19th / 20th dynasties.[30]

- The second model is a glass bottle from the 19th dynasty displayed in Metropolitan Museum of Art and shown in Fig.17.[31] It has a small mouth, round rim, small neck, spherical body, point base and two medium handles between the neck top and the shoulder of the bottle. It is manufactured from dark-blue glass. The rim is orange, the body is decorated by three thin bands in yellow and wavy trails over about 60 % of the body in pale-blue and orange colors in an interchanging pattern. The handles are not decorated. The neck as zoomed in Fig.17 (b) is decorated by colored feathers in vertical columns in pale-blue, orange and dark-blue colors.

(a) Bottle **(b) Zoomed neck**

Fig.17: Glass bottle from the 19th / 20th dynasties.[31]

- The last model from the 19-20 dynasties is a 92 mm length kohl tube displayed in the Metropolitan Museum of Art and shown in Fig.18.[32] It simulates a papyrus stem that is used in a large-scale production of temple-columns.[33] It is manufactured from a dark-blue glass and has a flaring round rim filleted to the cylindrical body and a flat base. It is decorated by 4 hands below the rim two in pale-blue and two in orange colors, a set of vertical lined from the first band up to the rim and a set of wavy trails on the bottom 40 % of the body in pale-blue and orange (or yellow) colors.

Fig.18 92 mm glass kohl tube from the 19th - 20th dynasties.[32]

CONCLUSION

- The production of glass vessels was investigated during the Middle and New Kingdoms of ancient Egypt.
- Ancient Egyptians could produce colored glass vessels since the Middle Kingdom.
- They developed white, dark-blue, pale-blue, green, yellow and orange glass colours.
- The manufactured glass vessels without handles, with one handle, with two handles and with four handles.
- They designed glass vessels with and without lid.
- They decorated their glass vessels partially or completely on the external surface in a very highly sophisticated and professional manner.
- Their decorations took the shape of wavy trails, feathers, plant-stems, hatching lines and curves and straight bands.
- They could manufacture a decorated glass jug with hen-head-spout in the Middle Kingdom.
- They manufactured coloured glass cups for Pharaoh Thutmose III (more than 3440 years ago) of the 18th dynasty.
- Wonderful designs, production and decoration of glass vases appeared in the 18th dynasty of the New Kingdom.
- Amazing models of glass vessels were manufactured for Pharaoh Amenhotep III (more than 3365 years ago) and Pharaoh Akhenaten (more than 3350 years ago) of the 18th dynasty.
- They designed vessels without neck, with short, medium and with long necks.
- There were great variety in the design of the vessel base. They designed glass vessels with point base, round base, small flat base and flaring-flat base, necked base, base without neck, decorated base and undecorated base.

- They could produce cosmetic vessels in the New Kingdom simulating fish and papyrus plant. The fish-shaped vessel was marvellous in design, production and decoration.
- The body of the glass vessels manufactured in ancient Egypt during the Medium and New Kingdoms took the shape of ovoid, double conical, spherical and cylindrical.
- There was a great variety in the location of the vessel handles: on the neck, on the body, on the neck and shoulder and on the shoulder.

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