International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Mechanical Engineering in Ancient Egypt, Part I: Furniture Industry

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

***Abstract*— This research paper presents the first part in a series of research papers investigating the history of mechanical engineering during the great civilization of the ancient Egyptians. It deals with some important aspects and examples of the ancient Egyptian furniture industry during a period extending from the 1st to the 19th dynasties. The paper coves some furniture's such as beds, chairs, tables and boxes. The examples presented highlight the design and production of furniture products that could survive for thousands of years. The ancient Egyptians have left tools for authorizing their furniture industry. Those products remains good examples of the engineering work in ancient Egypt providing outstanding styles that can be used up-to-date.**

Keywords*— *History of mechanical engineering; furniture industry; ancient Egypt civilization; .

I. INTRODUCTION

This is the first paper in a scientific research aiming at presenting a deep insight into the history of mechanical engineering during one of the greatest civilizations in the world, the ancient Egyptians civilization. The papers handles the furniture industry as an indication of people living at this period of the human being life. It covers a historical period starting from the first dynasty (3100-2890 BC) to the 19th dynasty (1293-1185 BC).

Smith (1960) presented a useful handbook on the Egyptian collection in the Museum of Fine Arts at Boston. His collection covered furniture items from queen Hetepheres from the 18th dynasty, bed from Kerma of the middle kingdom, tables in a tomb in Bershah from the middle kingdom and drawing for a chair of king Thutmos IV of the 18th dynasty [1]. Scott (1965) declared that Egypt is the pleasantest antiquity-producing country in the world. He stated that king Snefru, the first king of the 4th dynasty brought 40 ships filled with cedar wood from Lebanon. He presented some furniture samples of the ancient Egyptians such as a carpenter's workshop from the 6th dynasty, bow drill from the 20-22th dynasties, adze from the 18th dynasty, square from the 11th dynasty, stool from the 17th dynasty, folding stool from the 12th and 18th dynasties, headrests from the middle kingdom, bed frame from the 1st dynasty, beds from the 17th and 18th dynasties, 3-legs bed of Hesi-Re from the 3rd dynasty, chests from the 18th dynasty, table from the 17-18th dynasty, cosmetic chest of Kemu-ny from the 7th dynasty [2]. Killen (1994) studied the woodworking, materials, fittings and furniture in Egypt. He covered various periods of Egypt since the predynastic up to the late and Roman periods [3]. Fischer (1996) presented some ancient Egyptian furniture in his studies about ancient Egyptians. He studied new kingdom chairs giving names of all chair elements. He analysed te chair of Rn-i-snb of the 18th dynasty showing its pattern of cords in the seat and a chair scene from middle kingdom [4].

Gurrl, Straker and Moore (2001) presented an overview of the ancient and modern history of Western seating with particular emphasis on the design influences over 5000 years period. They repeated the statement of Geidion that the Egyptians equipped their houses with great skill. They presented some samples of the ancient Egyptian furniture such as stools, chairs and footstool [5]. Burrows (2005) repeated the words of Lucas and Harris that woodworking reached high degree of skill during the old kingdom. He presented the nice bed of Yuya and

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Tuya of the 18th dynasty, a nice chest in the Egyptian Museum, chair and stool for king Tutankhamun [6]. Goodwin (2006) presented a number of furniture products from ancient Egypt including a foldable stool from of Engineer Kha of the 18th dynasty, curved-strengthened stool of Kha and three legs stool, rounded legs stool from the 18th dynasty [7].

Harcombe (2011) focused on the development and evolution of the theriomorphic category of furniture legs in ancient Egypt. He showed that they simulated animal legs in their furniture industry since the first dynasty manufactured from hippo and elephant ivory. The ancient Egyptians continued using animal legs designs during the old and middle kingdom. This style of furniture legs was extended to the 26th dynasty and even to the Greco-Roman period [8]. Ahmed (2014) highlighted the furniture in ancient Egypt through scenes on tombs walls and through real models and pieces found in Egypt. He highlighted the design of chairs and stools in the different dynastic eras. He showed how the ancient Egyptians decorated their chairs with plants and flowers. He also presented scenes from tombs about the furniture industry and carpenters activities [9].

II. BEDS MANUFACTURING

Beds are domestic products indicating the level of civilization of societies. The old Egyptians manufactured beds since the era of the first dynasty (3100 – 2890 BC). Fig.1 shows a bed frame supported by four legs simulating cow legs. It had straight lateral and longitudinal sides The bed was manufactured from wood and still existing in Manchester Museum [2].

Fig.1 Bed frame with straight sides from the first Egyptian dynasty [2].

Another model from the first dynasty with curved longitudinal sides is shown in Fig.2. It exists in the Oriental Institute of Chicago University [10].

Fig.2 Bed frame with curved sides from the first Egyptian dynasty [10].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

In the third dynasty (2686-2613 BC), the old Egyptian manufactured beds having only three legs found in the tomb of Haisy at Saqqara. A line diagram of such beds of three legs is shown in Fig.3 as presented by G. Killen [3].

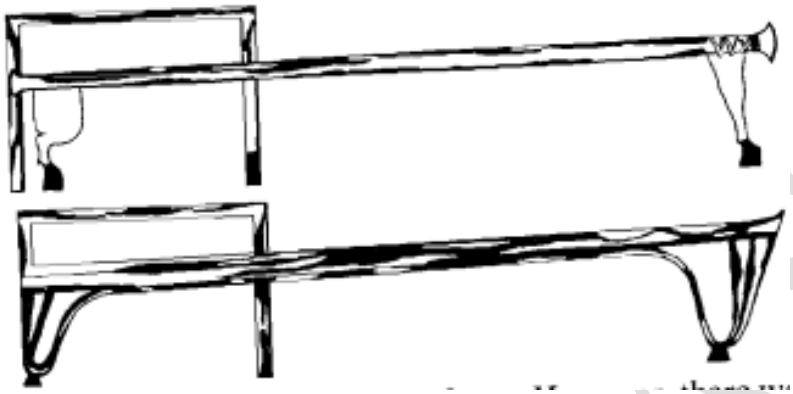


Fig.3 Egyptian bed from the third dynasty [3].

In the fourth dynasty 2613-2494 BC), the ancient Egyptians manufactured well designed beds very close to the styles of nowadays. Fig.4 shows a bed belonging to queen Hetepheres, the wife of king Sneferu , the first king of the 4th dynasty [11]. The sides are straight and the legs simulate line legs.

Fig.4 Queen Hetepheres bed from the 4th dynasty [11].

In the 18th dynasty (1570-1293 BC), they manufactured bed from wood gilded by golden sheets. Fig.5 shows one of such beds for king Tutankhamun [12]. It has curved longitudinal sides and legs simulating lion legs. It is shielded completely by gold sheets.

Fig.5 King Tutankhamun bed from the 18th dynasty [12].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Another bed of king Tut is shown in Fig.6 [13]. The bed has a frame manufactured from ebony wood and has a lateral curved sides with two lion heads decorating the bed. It has a stuffing grid.

Fig.6 King Tut bed of lateral curvature [13].

The ancient Egyptians could manufacture foldable beds composed of several parts and joined by revolute joints. Fig.7 shows one of those sophisticated beds consisting of three parts and 8 legs. It belongs to king Tut and has an 1.80 m length and grid stuffing knitted from papyrus threads [11].

Fig.7 King Tut foldable bed [11].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

They have produced also funeral beds used in the ceremony of dead burial. There were different styles of such beds. Fig.8 shows one funeral bed for king Tut of the 18th dynasty [11]. It simulates two horses standing one besides the other. Its length is 2.34 m and manufactured from golden wood. The horses eyes are from coloured glass.

Fig.8 King Tut funeral bed [11].

III. CHAIRS MANUFACTURE

The ancient Egyptians were clever in producing different styles of chairs: Chairs without back and arms chairs with back and chairs with both back and arms.

- ***Chairs without back and arms****:* Fig.9 shows a wall inscription of a chair without back and arms from the middle kingdom [4]. The chair legs simulate the legs of a horse.

Fig.9 Chair without back and arms [4].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Another models of chairs without back and arms are shown in Fig.10 [10]. They are colored wall inscription for three men set on a symmetrical chairs. The legs are exactly vertical and strengthened by four truss elements.

Fig.10 Three chairs without back and arms [10].

Fig.11 shows a high quality chair without back and arms produced by ancient Egyptians from ebony wood and inlayed by ivory [6]. The seat has curved longitudinal and lateral aprons. The legs simulate the legs of a lion and strengthened by horizontal and vertical supports.

Fig.11 Ebony chair without back and arms [6].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

The top technology in the manufacturing of this type of chairs appears in the distinct chair shown in Fig.12 from the middle Egyptian kingdom (2000-1700 BC) [14]. It is a foldable chair with two revolute joints, each joint joins two legs together (folding mechanism). The seat has curved aprons from all sides. The legs simulate a duck head and neck. The foot is held in position by the duck mouth. The seat is covered by a very neat and nicely decorated napkin.

Fig.12 Foldable chair without back and arms [14].

- ***Chairs with back and without arms:*** Fig.13 shows a statue for king Amenhotep III from the 18th dynasty setting on a chair with a short back, without side arms and with feet stand as shown in Fig.13 [15].

Fig.13 Amenhotep III setting on a chair with a short back and without arms [15].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Another style of the short back chair is shown in Fig.14 [16]. It is supported by two long bases allowing the chair to be carried by two men while an ill man is setting on it.

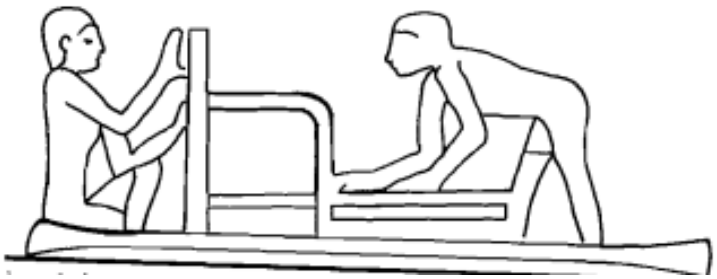


Fig.14 Carrying chair with short back and long base [16].

They produced also chairs with medium back from early dynasties. Fig.15 shows a drawing for a statue from a tomb at Saqqara from the 2nd dynasty [17]. The back has a medium height and the base is extending just to suit the feet of the setter.

Fig.15 Chair with medium back and short base [17].

Fig.16a shows a wall inscription for a chair with long back from the second dynasty. It has no arms and the legs are strengthened by horizontal cantilevers. The base is extending outside the projection of the chair allowing the setter on the chair to put his legs on it. Fig.16b shows a well manufactured typical chair with long back from the new kingdom which is located in the Metropolitan Museum [18]. It is painted by a black colour paint and its base is white while the back has both white and black colours

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

.

Fig.16a Chair with long back and extending Base (second dynasty).

Fig.16b Actual chair from the new Kingdom [18].

Fig.17 shows a colored wall inscription for a Egyptian ladies ceremony. All the chairs have the same long back without arms design. The legs have no side or longitudinal supports.

Fig.17 Chairs with long back without arms.

Fig.18 shows the top quality of this type of ancient Egyptian chairs. It belongs to king Tut of the 18th dynasty [19]. It is the throne chair with long back with extensive decorations and cylindrical seat, The legs simulate a bird head and neck. The chair lies in the Egyptian Museum.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Fig.18 Chair of King Tut at the Egyptian Museum [19].

- ***Chairs with back and arms***: Fig.19 shows a typical chair with back and arms belonging to queen Hetepheres from the 4th dynasty and located in the Egyptian Museum [12]. The chair legs are straight and vertical, the seat is flat, the back has a medium height and the arms have less height than the back and strengthened and decorated by Lotus models tightened together.

Fig.19 Chair of queen Hetepheres at the Egyptian Museum [12].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Fig.20 shows one of the top quality chairs of this type. It belongs to king Tut of the 18th dynasty which is located in the Egyptian Museum [11]. The back is curved and decorated by a drawing for the king and his wife. The arms are hold by Horus and almost have half the height of the chair back. The legs simulate lion legs and each front leg is ended by the head of a line. The legs are supported horizontally and vertically. The body is made of wood shielded by gold and silver sheets and decorated with semi-precious stones and colored glass. The king and queen drawing is inlayed with silver and colored glass.

Fig.20 Chair of King Tut at the Egyptian Museum [11].

Another chair design with back and arms is shown in Fig.21. It belongs to Yoya and Toya from the 18th dynasty [20]. The back is one slightly curved piece and decorated. The arms are almost half the back height and are gradually increase in height to the full height at the back. The seat is a grid to provide more comfort to the setter. The legs are curved and simulate an animal legs and decorated by the head of a woman at its top start for the front two legs.

Fig.21 Chair of Yoya and Toya from the 18th dynasty [20].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

IV. STOOL CHAIRS

Because ancient Egyptians were a civilized community, they produced stool chairs. They are relatively small chairs and another type is used as a mobile toilet. Physical evidences illustrate that they used stools in workshops and saloons. Fig.22 (a) shows short stools used in a woodworking workshop from the tomb of Rekhmire of the 18th dynasty [20a] . They are 3-legs stools and have short legs.

Fig.22 (a) Stools from Rekhmire's tomb [20a].

Another short legs stools appeared in a barbering shop as a scene in the tomb of Userhat of the 18th dynasty {Fig.22 (b) [20b]}.

Fig.22 (b) Stools from Userhat's tomb [20b].

Another stool frame from the 12th dynasty is shown in Fig.23 [21]. It has four legs decreasing gradually towards the feet. The foot increases gradually towards its end at the ground giving better stability for the structure. It is located in the Ashmonian Museum at Oxford, UK.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

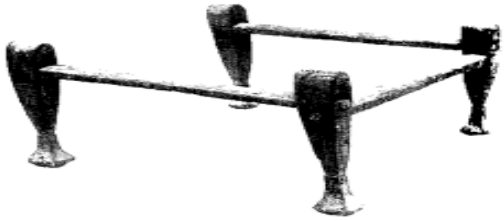


Fig.23 Stool frame from the 12th dynasty [21].

They produced stools of three legs and having a minimum size such that shown in Fig.24 from the new kingdom (1570-1070 BC) [22]. The legs are extended outwards to provide better stability and smooth seat with the hole in its centre. The stool is still existing in the National Museum of Scotland as a witness on the greatness of the old Egyptian production technology.

Fig.24 Three legs stool chair from the new kingdom [22]

The stool chair of king Tutankhamun of the 18th dynasty is shown in Fig.25 [9]. It has three curved legs, elliptical seat, smooth filleted hole and minimum seat thickness to decrease its weight.

Fig.25 Three legs King Tut stool chair from the 18th dynasty [9]

V. TABLES MANUFACTURING

The ancient Egyptians were in need to produce tables for food and fruits presentation, activities of religious ceremonies, supporting amusing devices, supporting industrial tools, etc.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

They manufactured tables with different distinct designs. Fig.26 shows a table from the first dynasty with miniature legs. The table is existing in Manchester Museum, UK [23].

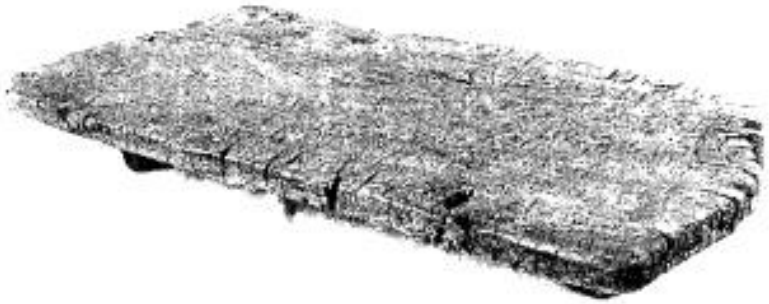


Fig.26 Table from the first dynasty [23].

Short legs tables were used by ancient Egyptians as game tables. Fig.27 shows a typical table with drawer from the 11th dynasty supporting a hounds and jackals game [24].

Fig.27 Hounds and jackals game table [24]

For amusing using small playing stations, they produced tables of different heights. Fig.28 shows tables with medium height for the senet game played by queen Nefertari , the wife of great king Ramesses II [25].

Fig.28 Senet table of queen Nefertari [25].

They used tables in various applications. Fig.29a shows a scene for a short legs table used in funerary practice in the mastaba of Qar from the 5-6th dynasties [26].

Fig.29 (a) Short legs table from the 5-6th dynasties [26].

Another application for medium length legs tables (about 0.4-0.5 m height) used in a jewellery workshop is shown in Fig.29 (b), a scene from the tomb of Sobekhotep of the 18th dynasty [27].

Fig.29 (b) Medium length table in a jewellery workshop [27].

In the middle kingdom (2055-1650 BC) they produced very well designed tables similar to the designs available nowadays. Fig.30 shows an existing model of such designs [2]. The table has a plate extending out of the main chassis of the table. The legs are straight and strengthened by cantilevers at the beginning and middle.

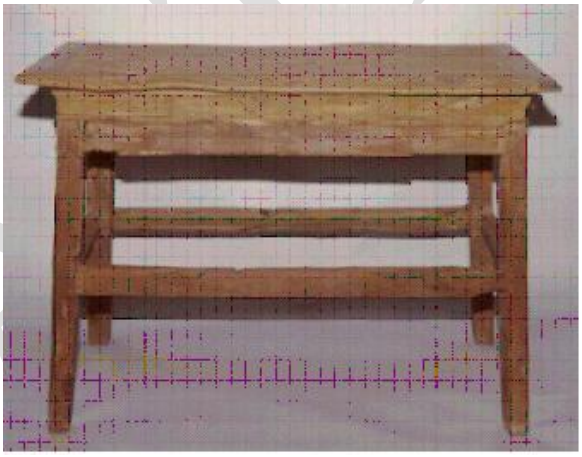


Fig.30 Table from the middle kingdom [2].

The old Egyptian manufactured long narrow table to support flower vases. Fig.31 shows an actual model from the old kingdom (2780-2263 AC) [10]. It has 6 curved legs with minimum dimension at its top and maximum dimension at the ground. There is more curvature at its top to hold the vase and an extended feets for more stability on the ground.

Another model for the vase table from the modern or new kingdom (1570-1070 BC) is shown in Fig.32 [28]. It has four straight legs inclined to give minimum dimension at the vase. The top surface is flat for better stability for the vase. The structure is strengthened by 4 elements truss. This model is still surviving at the British Museum.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

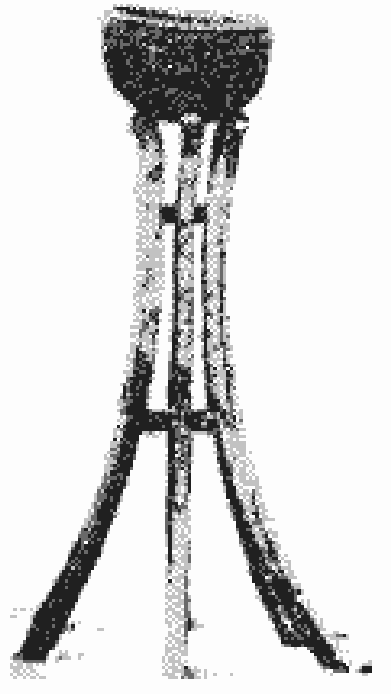


Fig.31 Vase table from the old kingdom [10]. Fig.32 Vase table from the new kingdom [28].

They manufactured tabled with three legs as shown in Fig.33 [29]. This table was manufactured on 1450 BC (18th dynasty).

Fig.33 3 legs table from the 18th dynasty [29].

The generous Egyptian carpenters designed tables with only one leg with varying radial cross-sectional area as that shown in Fig.34 at the back of the statue of Yuny and Renenutet from the 19th dynasty [30]. Another model appears in a papyrus written in 1025 BC (21st dynasty) and shown in Fig.35.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

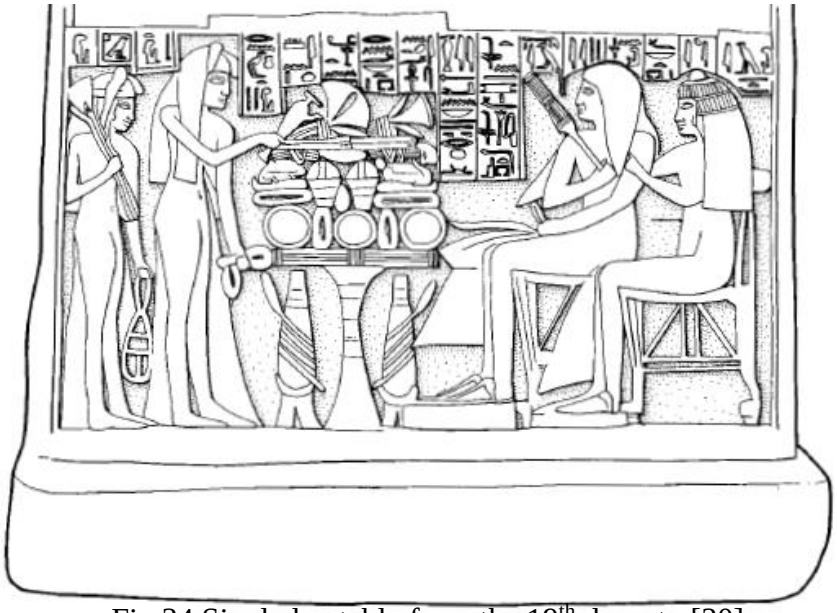


Fig.34 Single leg table from the 19th dynasty [30].

Fig.35 Single leg table from the book of dead [31].

VI. FOOT STAND MANUFACTURING

The ancient Egyptians produced foot stands to be put underneath the feet of kings and noble officials of the state. A sample of such stands which is a mobile stand appears in Fig.36 where it belongs to king Tut of the 18th dynasty. It is colour-painted and decorated by 9 symbols referring to the enemies of Egypt (as they are underneath the feet of the king) [11]. Dimensions: 80 x 320 x 8560 mm. The decoration and colours survived for thousands of years.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Fig.36 Mobile foot stand of king Tutankhamun [11].

VII. BOXES MANUFACTURING

Ancient Egyptians was in need to boxes to store their cloths, tools, cosmetics, etc. They manufactured magnificent boxes ranging from simple to very accurate and high quality products still surviving till now for thousands of years.

Fig.37 shows a box from the old kingdom (2780-2263 BC) with a handled flat lid from the top and a handled drawer from the side. It is coloured and has two short legs [32].

Fig.37 Box from the old kingdom [32].

The old Egyptians manufactured boxes with lids having a pyramid-shape and arbitrary shape as shown in Fig.38. Those boxes were found in the tomb of Benu in Saqqara from the 6th dynasty (2345-2181 AC) [33]. The box to the left has a lid with smooth curved surface not to harm its user. Legs are short.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

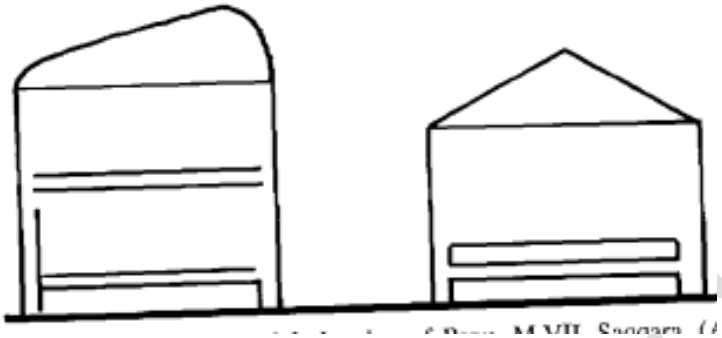


Fig.38 Boxes from the 6th dynasty [33].

They manufactured very neat decorated boxed for the kings. A sample is shown in Fig.39 for king Tutankhamun of the 18th dynasty (1570-1293 BC) [35]. The lid of the left box has a gradually increasing height from left to right while that of the right has a cylindrical shape , both with handle near the left side. The boxes have short legs and decorated from all its sides.

(a) (b)

Fig.39 Boxes for king Tut of the 18th dynasty [35].

They manufactured boxes without any legs. Fig.40 show a box from the tomb of queen Merry Sankh from the 3rd dynasty (2686-2613 BC) [36]. It has a cylindrical top (or cover). Another model without any legs is shown in Fig.41 from the working town at Kahoon of the 12th dynasty. It is simple without any decoration [37].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

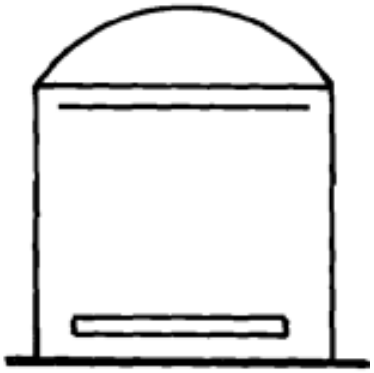


Fig.40 Box from the 3rd dynasty [36].

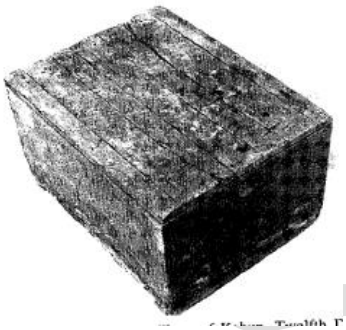


Fig.41 Box from the 12th dynasty [37].

Another model of boxed without legs is shown in Fig.42 for king Tut of the 18th dynasty [38]. It simulates the king Cartouche , decorated on the cover, handle for the cover and side handles for the whole box. A wonderful model is shown in Fig.43 for a canopy box for Yoya from the 18th dynasty [39]. It is inlayed by gold and painted by black lacquer. The cover represents the roof of a compartment. It has a reptile to facilitate pulling the box. Its length is 0.8 m and located in the Egyptian Museum.

Fig.42 Box without legs for king Tut of the 18th dynasty [38].

Fig.43 Box without legs for Yoya of the 18th dynasty [39].

They used extensive and wonderful decorations for some of their boxes. Samples are for the architecture engineer Kha from the 18th dynasty (Fig.44) [40] and for king Tutankhamun (Fig.45) [41]. Their decorations have various colours and invory inlays with black ink writing (for Kha) or military war scene (for king Tut).

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Fig.44 Decorated box for engineer Kha [40] Fig.45 Decorated box for king Tut [41]

They also produced boxes with long legs as that shown in Fig.46 which belongs to king Tut [42]. It has four straight long legs without any strengthening elements. red handles are used for the cover and box body. The box is decorated by fiancé from all its sides.

Fig.46 Long legs box for king Tut [42]

VIII. JOINTING OF WOOD PIECES

Wood products consist of a number of pieces or parts. The engineering technician has to be familiar with different techniques for wood jointing. The ancient Egyptian technicians were so clever in everything including jointing techniques. Some of there jointing techniques were as follows:

- *Using fixed joints*: Through using glue applied by a brush as shown in Fig.47 for a carpenter applying glue in the tomb of Rekhmire of the 18th dynasty [43].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

Fig.47 Glue fixed joints in from the 18th dynasty [43]

- *Using revolute joints*: The ancients Egyptians have known revolute joints and produced them from wood or bronze. Fig.48 shows a typical wood revolute joint from the late period (1085-332 BC) located in the British Museum of UK [43].

Fig.48 Revolute joint from the late period [43].

- *Using prism joints*: They used prism joints consisting of poles and rectangular holes to allow dismantling furniture components without damaging them. Fig.49 shows a prism joint used in the manufacturing of a bed during the 1st dynasty [44].

Fig.49 Prism joint from the 1st dynasty [44].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

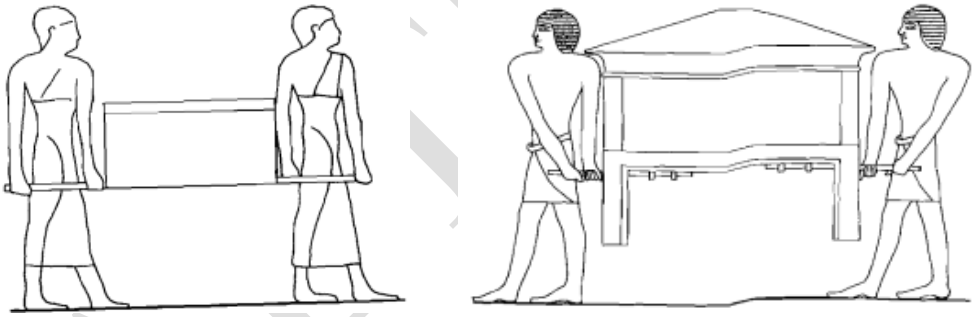
IX. AUTHORIZATION OF THE FURNITURE INDUSTRY

The ancient Egyptians were so clever and has sophisticated administration systems and technologies. One of their administration techniques is authorizing their deeds including the furniture industry. This was through:

- Wall inscription of the ceremony of moving the furniture as shown in Fig.50 [45].

Fig.50 Moving furniture by men [45]

- Wall inscription of moving separate furniture pieces as shown in Fig.51 [9].



4th dynasty, Tomb of queen Merry Sankh (the 3rd). 6th dynasty, Tomb of Meriroka

Fig.51 Moving individual furniture peaces [9].

- Wall inscription for recording the amount of production of wood pieces: Fig.52 shows an administration process of recording the wood cutting process to prepare wood strips required for the furniture industry from the tomb of Nipamin and Eiboki from the 18th dynasty[46]. The cut wood is put in a stack to be ready for transportation.

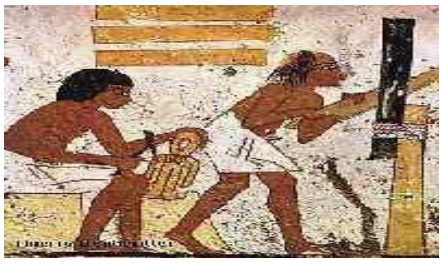


Fig.52 Production recording in the 18th dynasty [46].

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume 3 Issue 1 JANUARY2016 ISSN No: 2349-3224

- Producing models for complete carpentry workshops: A sample of such workshops is shown in Fig.53 [6]

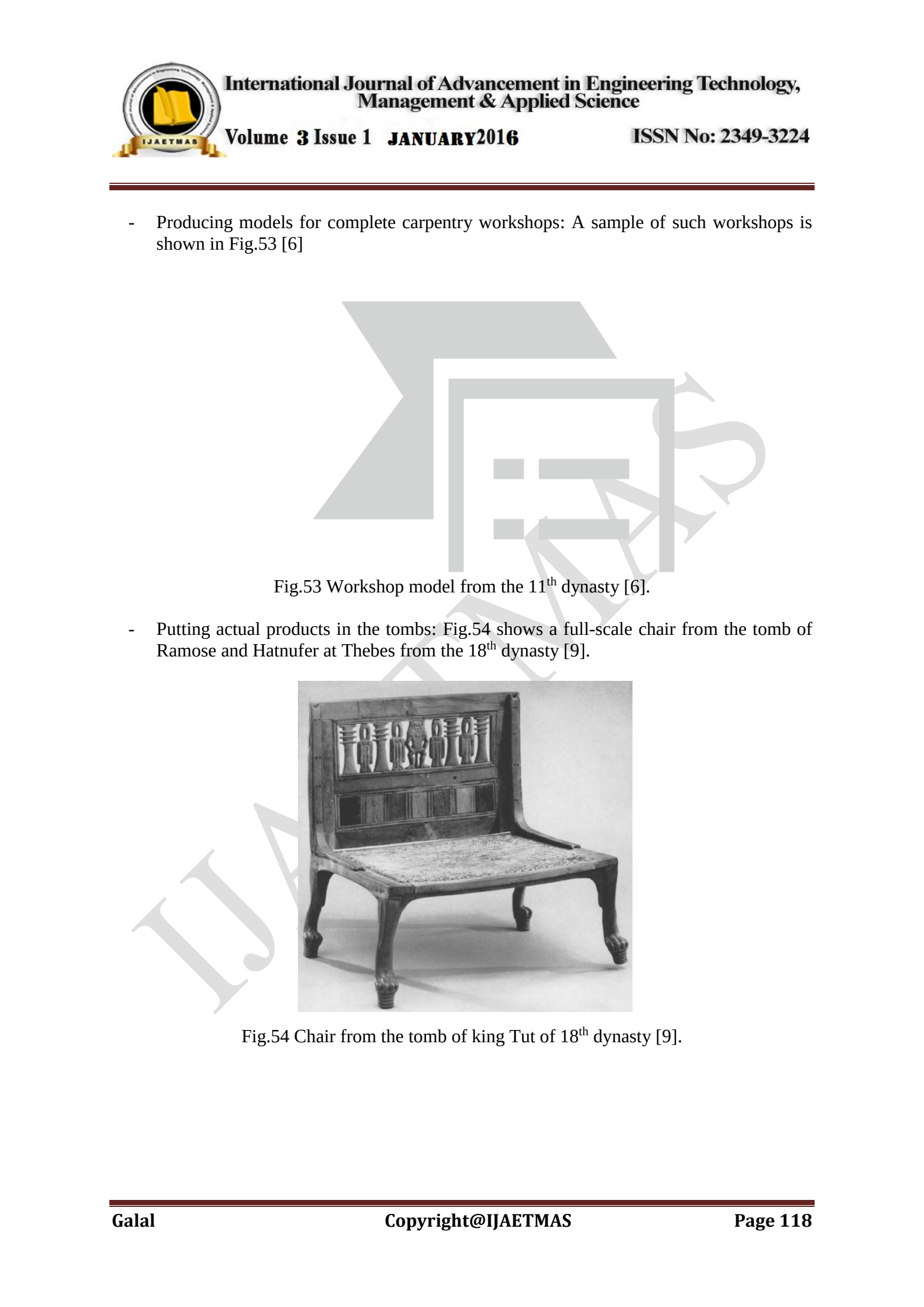


Fig.53 Workshop model from the 11th dynasty [6].

- Putting actual products in the tombs: Fig.54 shows a full-scale chair from the tomb of Ramose and Hatnufer at Thebes from the 18th dynasty [9].

Fig.54 Chair from the tomb of king Tut of 18th dynasty [9].

X. CONCLUSIONS

- Some of the features of the ancient Egyptian furniture were investigated and illustrated.
- The study covered some important wood products such as beds, chairs, tables and boxes.
- The furniture of the ancient Egyptians was recorded and authorized since the first dynasty.
- The ancient Egyptians designed wood beds with three and four legs.
- In most of the bed designs, the legs simulated animal legs.
- They gilded beds of kings and princesses by gold in the 18th dynasty.
- They designed beds with straight or curved sides.
- They could produce foldable beds in the 18th dynasty.
- The produced funeral beds in the form of a standing animal.
- They produced various designs of chairs without back and side arms, with back and without side arms and with back and side arms.
- They could produced very wonderful foldable chairs using revolute joints.
- The designed chairs with short, medium and long back.
- They designed special chairs to be carried by porters.
- They produced very magnificent chairs for king Tutankhamun.
- They applied wonderful decoration for the fur nature of kings and princesses.
- They used stools of three and four legs for different applications.
- They designed and produced tables of various configurations and applications. Some of the features were, using drawers, short, medium and long legs and 3, 4 or 6 legs.
- They designed foot stands either mobile or integrated with chairs.
- They designed and produced boxes with varying quality depending on the application. Some of the designs had drawers, lids, lid handle, carrying handles, no legs, short legs and long legs.
- They used glue, revolute joints and prism joints to join wood elements together.
- They left strong various evidences to authorize their furniture industry.

REFERENCES

[1] W. Smith, "Ancient Egypt", Museum of Fine Arts, Boston, 1990.
[2] N. Scott, "Out Egyptian furniture", The Metropolitan Museum of Art Bulletin, vol.24, issue 4, pp.129-148, December 1965.
[3] G. Killen, "Egyptian woodworking and furniture", Shire Publications Ltd., 1994.
[4] H. Fischer, "Egyptian studies III", The Metropolitan Museum of Art, NY, 1996.
[5] K. Gurrl, L. Straker and P. Moore, "A history of seating in the Western world", Curtin University of Technology, Western Australia, Open Publication, 2001.
[6] A. Burrows, "Woodworking in ancient Egypt, Part I: Workshops and palace", Archaeological Digging, vol.4, pp.42-45, January 2005.
[7] J. Goodwin, "Egyptian furniture: Encient and revivals", Antique collecting, 3 pages, July/August 2006.
[8] M. Marcombe, "A chronolical study of theromorphic furniture legs from ancient Egypt", South Africa Society Near Eastern Studies Conference, pp.1-18, 5-6 September 2011.
[9] A. Ahmed, "Furniture industry through the real models and scenes in the ancient Egyptian art: Chairs, stool models", Research Mobilis, vol.3, issue 3, 21 pages, 2014.
[10] www.reshafim.org/ad/egypt/timelines/topics/furniture.htm.
[11] www.eternalegyot.com/
[12] mesrana-blogspot.com.eg
[13] www.al-7up.com
[14] www.touregypt.com

[15] Killen, p.109.
[16] Killen, p.32.
[17] Killen, p.11.
[18] Fischer, p.160.
[19] www.renecislayartist.com/ancient-egyptian-art-and-pottery/
[20] www.qudamma.com/vb/showthread.php?t-32183
[21] Killen, p.37.
[22] Killen, p.46.
[23] Killen, p.26.
[24] www.ancient-egypt-online.com/ancient-egypt-games.html
[25] Labyrinthgameshop.blogspot.com.eg/2013/08/ancient-games.html.
[26] M. Martin, "Hair and death in ancient Egypt", hairanddeathinancientegypt.com/page/4/, November 2014.
[27] www.gettyimages.co.uk/
[28] www.arab-ency.com/ar/الأثاث/ البحوث
[29] J. Ranganathan, "History of furniture design", www.slideshare.net/mickeyjar/furniture
[30] www.qudamma.com/
[31] https://memphistours.files.wordpress.com/2010/11/book-of-the-dead.jpg
[32] www.kingtutshop.com/
[33] Killen, p.35.
[34] Egyptopia.com/
[35] www.globalegyptianmuseum.org
[36] Killen, p.34.
[37] Killen, p.41.
[38] www.touregypt.net/museum/tut139.htm
[39] www.qudamma.com/vb/showthread.php?t=32183
[40] Turin Museum, "The tomb of Kha", www.deirelmadina.com/lenka/TurinKha.html
[41] www.archaeology.land/forums/viewtopic.php?t=34473
[42] www.hellenicaworld.com/Egypt/Geo/en/EgyptianMuseum.html
[43] Killen, p.18.
[44] Killen, p.24.
[45] Scott, p.146.
[46] Wikipedia, "Woodworking".
[20]a https://paulsmit.smugmug.com.....,L/29358-egypt-1.jpg
[20]b imagenesdeegiptspot.com.eg/2015_08_archive.html

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 160 research papers in international journals and conferences.
- Author of books on Experimental Systems Control, Experimental Vibrations and Evolution of Mechanical Engineering.
- Chief Justice of International Journal of Computer Techniques.
- Member of the Editorial Board of a number of International Journals including IJAETMAS.
- Reviewer in some international journals.
- Scholars interested in the author's publications can visit:

http://scholar.cu.edu.eg/galal