The Mechanical Engineer: Abu'l –'Izz Badi'u'z – Zaman Ismail ibnu'r – Razzaz al Jazari

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Abstract

During the Islamic golden age, there are many Muslim scholars that are really great and contribute a lot. A few common names such as Ibn Sina, al Biruni and al Khawarizmi always be known for their contributions. Also there are figures that is an icon in the mechanical engineering field which is Abu'l –'Izz Badi'u'z – Zaman Ismail ibnu'r – Razzaz al Jazari. His creation helps people ease their jobs. Al Jazari is the first person that has been created and constructed hydraulic and gear system. He also known as the person that creates humanoid robots and was called as Father of Robotics. The story of his life before he became an honorable person is inspiring. His creations has been references for people all around the world including the west.

Keywords: *muslim, mechanical engineer, hydraulic and gear system, humanoid robots*

1.0 Introduction

According to MacMillan English Dictionary for Advanced Learners, engineering is defined as the activity of designing things such as roads, railways, bridges or machines. Engineering is a wide discipline that can be divided into several sub-disciplines. These disciplines concern themselves with differing areas of engineering work. Usually, engineers will be trained in a specific discipline, but throughout an engineer's career, the engineer may become multi-disciplined and worked in several outlined areas. Engineering is often characterized into four main branches. They are chemical engineering, civil engineering, electrical engineering and mechanical engineering.

According to MacMillan English Dictionary for Advanced Learners, mechanical engineering is science or profession of studying, designing or building machines. Therefore, mechanical engineering is a kind of discipline that applies the principles of engineering, physics and materials science for the design, analysis, manufacturing and maintenance of mechanical systems. It is the branch of engineering that involves the design, production and operation of machinery and tools. There are few examples of systems that used mechanical engineering such as power and energy systems, aerospace or aircraft products, weapon systems, transportation products, engines compressors, powertrains, kinematics chain, vacuum technology and vibration isolation equipment.

A mechanical engineer is a specialist in all fields related to machines, kinematics, thermodynamics and tools. Working as a mechanical engineer is known to be an enriching and rewarding experience and the job description involves working to plan, build and examine motor-powered vehicles, manufacturing plants, airplanes, industrial equipment, cybernetics and much more. Mechanical engineering has been applied in life a long time ago among Muslim

engineers. Among the Muslim mechanical engineers were Al- Jazari (1136- 1206), Al-Muradi (11th Century), Al- Zarqali (1029- 1087) and Taqi al - Din. All of them were outstanding mechanical engineers during their time and they did a lot of mechanical innovations.

In this paper, two most outstanding mechanical engineers in the Arabian engineering world will be discussed. They are Abu'l –'Izz Badi'u'z – Zaman Ismail ibnu'r – Razzaz al Jazari and Taqi al – Din Muhammad ibnu Ma'ruf. Their achievement gives great impact to the engineering world generally due to their innovations and even theoretical that has been written in books.

2.0 Abu'l –'Izz Badi'u'z – Zaman Ismail ibnu'r – Razzaz al Jazari

2.1 Background

Al Jazari's name is Ismail ibnu'r – Razzaz. His father and grandfather work as farmers in Ibn 'Umar Island which is located near to the southeast cliff of Dajlah River. This island is located approximately 1200 feet above sea level. Ibn 'Umar Island was opened by an Arabian commanders named 'Iyad ibn Ghun in 17 AH during the rule of 'Umar ibnu'l – Khattab. Al – Jazari was said to be born in 1150 AD and died 1220 AD. However, it is just an estimation since no one exactly knows exactly the date of birth and death of this figure. Also, the place of his tomb was buried was remain unknown.

Ismail al Jazari has shown his interest in mechanical engineering since he was a kid. It is said that he had shown his talents to his grandfather when he was 14 years old. He had built a mini waterwheel that pulled by a hornet. However, his father did not like al Jazari involved in engineering field so he was against it during that time. Meanwhile, al Jazari's grandfather was really support him. His grandfather helped and tried to find all books needed by him for his learning process. There was one time when he spent most of his time reading books and study others mechanical theories, his father came to him and asked him to be a farmer rather than sit and read books. He did not want his son wasting time without doing nothing and just do reading and researching. But, this did not made him gave up his dream. He kept reading and researching until he succeed. His father, finally realize his son talents when he saw Al-Jazari inventions. He was proud with him.

Al Jazari was having hard time during his study. He had learn alone without any teacher for 6 years. During that period, he had not have any books regarding to mechanical engineering field except Greek Encyclopedia which has been translated and written in Arabic. Then he started to read Greek books which has been translated such as ath – Thiqal wa'l – Khiffah (Light and Load) written by Iklidis, Sa'atul – Ma'allati Tarmi Bi'l – Banadiq (Water clock thrown by gun) written by Archimedes,al – Makhrutat by Ablunius and Raf'a'l – Athqal (To carry heavy loads) by Ahran. Also, al Jazari read books written by Murthis entitled al – Alatu'l – Musawwitatu'l – Musammah bi'l – Arghuni'l – Buqi wa'l – Arghun az – Zamari, ad – Dawalib and al – Alat Musawwitah 'ala Bu'd Sittin Milan (Shining tool from 60 miles). Besides that, he also read authored by Hayrun al – Iskandari entitled al – Alatu'l – Mufarrighah li'l – Hawa' and ar – Rafi'ah li'l – Miyah (Tools that can empty the air and pull water). Al Jazari also read books from al – Biruni, al – Khawarizmi, Thabit ibn Qurah, al – Kufi, al – Farabi, Ibn Sina, Qista ibn Luqa, Ibn Haytham, al – Jaldaki and many more.

Al Jazari then spent about 2 years and has created children toys than can moves. Besides that, he also created things that can be used by palace servants and things that can help housewives to clean up their house. Everyone seems to be very happy with al Jazari achievement. Al Jazari then serve the Gabenor Palace creating new tools and also train the craftsmen. After that al Jazari serve the Kaifan city before he moved to Diyar Bakr as he was invited by the Amir al – Artuqi Nasiruddin, the king of Diyar Bakr. As al Jazari arrived at the city of Diyar Bakr, al Jazari feels very secured and peace because at that time Muslims and Christians lives in harmony. Al Jazari spent nearly 25 years in Diyar Bakr. One of his creation is kettle that is used to take wudhu' for Amir al – Artuqi Nasiruddin.

On the year of 602 Hijra which equivalent to 1200 AD, Amir Nasiruddin has encouraged al Jazari to write books as the reference for future generations. Al Jazari then plans to write a book about mechanical engineering. Al Jazari divide the book into two important sections which is Handasatu'l – Mawani' (Hydraulic) and Handasatu'l – Harakah (Dynamic). The book is quite thick and divided into 3 sections. The book was entitled Kitabu'l – Hai'ah wa'l – Ashkal (Bodies and forms). Later, the book is known as Kitab Ma'rifati'l – Hiyal al – Handasiyyah (Knowing mechanical engineering) and Kitabu'l – Hiyal fi'l – Jam' Baina'l – 'ilm wa'l – 'Amal (The connection between science and religion). Al Jazari takes 2 years to complete the book. Also,one of the famous books that has been written by al Jazari was *Al-Jami 'bayn al- 'ilm wa 'l- amal al-Nafi' fi sina 'at al-hiya* or also known as The Book of Knowledge of Ingenious Mechanical devices. The book was about a summarization of theories and practices in mechanical art. The book contained tradition Islamic values which are very significant in mechanical engineering field. In this book, he also described about 100 mechanical devices like various kinds of trick vessels along with instructions on how to construct them. After 800 years of his death, the new modern science world still run research on his findings and gave him high recognition for his findings. The book still survived until now from 1206.

Among the modern scientist and engineers, the book that Al- Jazari wrote is still relevance to be used even though it was written hundred years back. Despite of being an inventor and engineer, Al- Jazari also a very talented artist. It was shown in the fine manuscripts written by him. There was a very precise details of all functions of his inventions accompanied with general drawing. For the complicated devices he gave detailed drawings for the components of the device or for subassemblies so that the operation can be understood. It was really helpful to all researcher who read and refer to his books. There are a total of 174 drawings in the book.

The book that he wrote described in detail fifty devices which are group into six categories. They are:

1. Ten water and candle clocks
2. Ten vessels and figures suited for drinking sessions
3. Ten pitchers and basins for phlebotomy and washing before prayers
4. Ten fountains that change their shape alternately and machines for the perpetual flute
5. Five water raising machines
6. Five miscellaneous devices

In the west, books by al Jazari has been translated into many languages suach as Latin. Mechanical devices that has been created plays an important role to the modernization devices.

Academician from the west such as Alder Miller, Sartre and Honketh really appreciate al Jazari for his contribution in the research on time, hydraulic and dynamic. Until now, the manuscript that has been written by al Jazari in Arabic can be found in Oxford,Dublin, London and few other places in Europe.

Being famous and talented in mechanical engineering field, had made Al- Jazari became the Father of Modern Engineering as well as the Father of Robotic. He was well known in robotic field because he created the humanoid robot.

2.2 Inventions

2.2.1 Al- Jazari's Water Supply System

This dispelled centuries old belief that it was Leonardo da Vinci (1452 –1519), the much honoured genius, who was attributed to be the first to develop and used hydraulics and mechanical gears. Credit for that invention should rightly go to Al- Jazari, who developed the system more than 200 years before Leornado, who was given the credit only because Al- Jazari's writings were in Arabic and not known to the West.

The researchers felt that it was highly likely that Leonardo was influenced by Al Jazari's writing because there were evidence of interactions between Leonardo da Vinci and the Ottoman Empire where Al Jazari had lived. In 1502, Leonardo produced a drawing of a single span 720-foot (220 m) bridge as part of a project for Ottoman Sultan Beyazid II of Istanbul.

This fact alone proved that there were communications between Leonardo and the descendents of Al Jazari's employer, Sultan Artuq in Turkey during the Ottoman period. Yet Leonardo's sketch was rejected because it was too impractical to implement.

Unlike many ancient texts which mostly are like a maze of philosophical riddles, Al Jazari's text was written to serve a practical purpose. It is like today's Do it Yourself (DIY) guide which focussed on practical instructions on how to construct his inventions. The researchers had to combine three expertise; history, engineering and language to come up with their findings.

2.2.2 Al- Jazari Water Raising Device

At a time when people still relied on wells and rivers as the sources for water, Al Jazari invented the mechanical devices that help to create a water supply system. Unlike Leornado Da Vinci who was famous and great in sketches that he made in his notes, Al Jazari successfully created a working and functional mechanical system operated by the devices he invented with great precision and accuracy. His water system comprised of four main devices which formed several basis of mechanical engineering today.

He was invented a water wheel that had a same effect as a turbine. The water wheel usually placed in the flowing water such as in the stream. When the flowing water hit the water wheel, the blades will rotate. This system used gear that connected to the water wheel. The gear rotated together with the water wheel rotation.

Al Jazari accomplished three things with this invention. Firstly, he had succeeded in inventing a gear which channeled water power from a water wheel to operate other devices.

Secondly, by using a unique combination of gears he was able to change the direction of the motion from vertical to horizontal. Thirdly, by connecting the main gear to a suction pump, he was able to create a piston like dual motion movements.

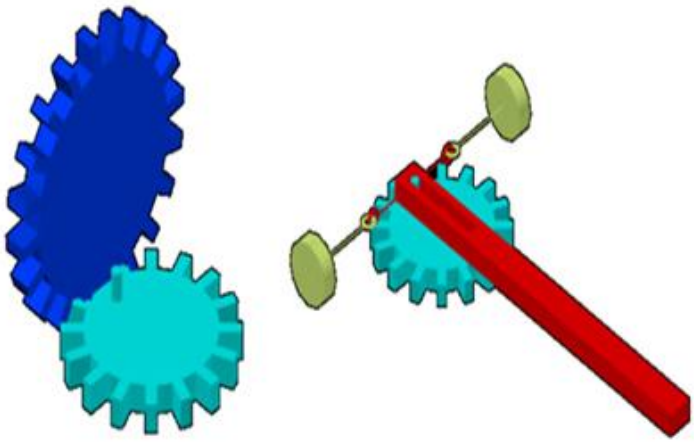

Figure 1: An illustration of vertical- horizontal gears

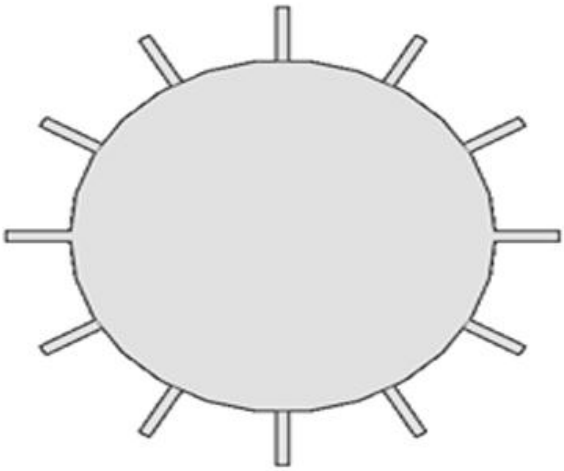

Figure 2: An illustration of a water wheel

He also had implemented the double- action suction pump with valves and reciprocating piston in his invention. By having a working and functional invention like this, it shows the depth of his knowledge. This pump used hydraulic power to pump water to another drain system. Al- Jazari drainage system had used the flowing water river to move a turbine with the helped of few gears for water suction system. With this water suction pump, the water can be spread to all areas not only far but also the higher areas. He used cylinders and a cover to create the hydraulic effect. He was really a great engineer with all his inventions.

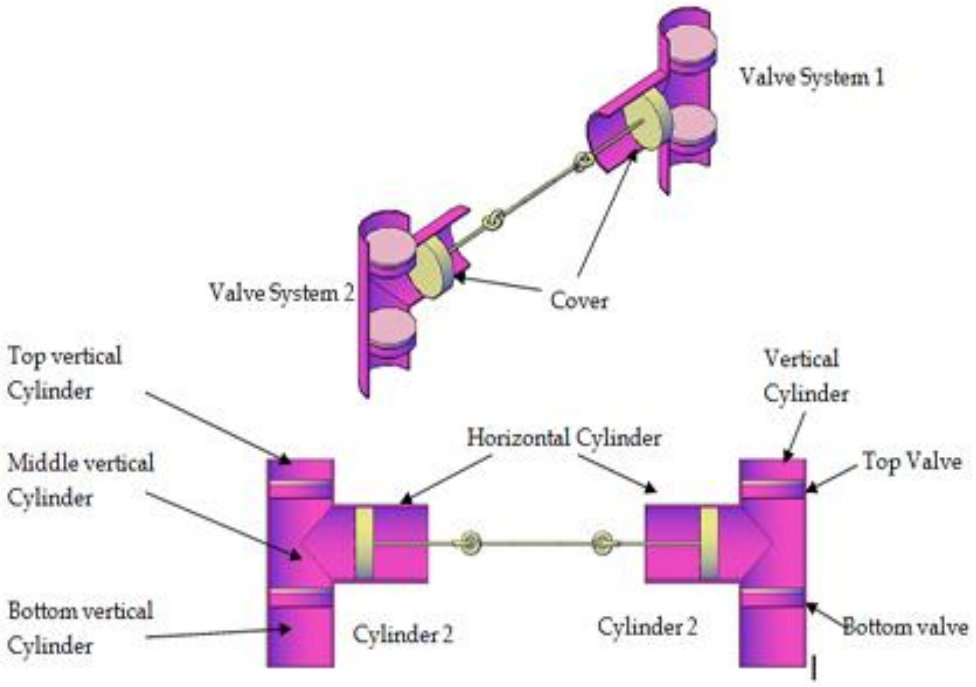

Figure 3: An illustration of hydraulic system

Al Jazari also was found out not only knew how to construct the pump, but he also chose the right material for the invention showing he knew about their properties. Specifically, the material used for the suction pump was copper which is known to be rust resistant and does not contaminate the water. Meanwhile, for the gears, he was made it from a mulberry wood. It is clear that he was not only a mechanical engineer but also an expert on materials and their long lasting properties.

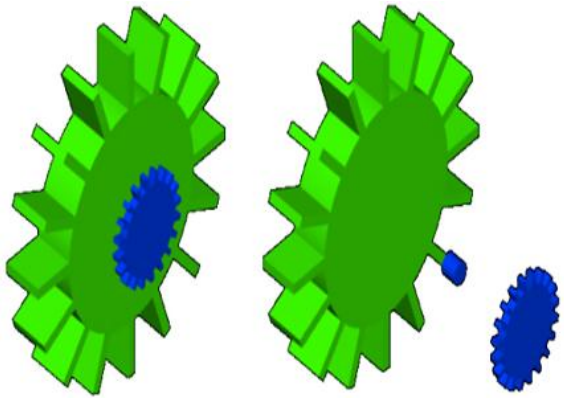

Figure 4: An illustration of gear made from mulberry wood

The ingenuity of Al Jazari's is clearly seen in his creativity in finding a power source and manipulating it exponentially. He used water as a power source to operate his pump to supply water. He turned the flowing water into useful energy which then was capable of operating a pump automatically and, finally the pump moved water from its source into a pipeline. It is fully automatic without the need of man power turning it on and off, so long as the water wheel was kept moving by the flowing stream.

2.2.3 Automata

Another invention made by him was the Automata. The automata humanoids waitress was made by Al Jazari to serve drinks at parties. It was driven by the hydropower. Other than the automata humanoids, he also invented the automated moving peacocks, automatic gates and automatic doors (as part of one of his elaborate water clocks). All of these inventions were using hydropower system.

Al Jazari is credited with creating the earliest forms of a programmable humanoid robot. Al Jazari automaton was originally a boat with four automatic musicians that floated on a lake to entertain guests at the Royal drinking parties. His mechanisms had a programmable drum machines with pegs (cams) that bumps into little levers that operated the percussion. The drummer could be made to play different rhythms and different drum patterns if the pegs were moved around.

Figure 5: An illustration of Al Jazari humanoids robots

3.0 Conclusion

Muslim engineers thought of inventions and methods in many fields of engineering, most of which have contributed significantly to modern technology, especially in the field of water and mechanical engineering. On 21 June 2010, group of researchers from Universiti Kebangsaan Malaysia (UKM) found that al Jazari is the first person that has successfully created and constructed water supply system to the mosque and hospital in Diyar Bakr, Anatolia,Turkey. Dr. Salehudin Mohamed Haris and Mohd Nur Khairulnizam Mohd Ghazali has studied two manuscript written by al Jazari and came out with a conclusion that al Jazari supposedly received the honor because he has invented hydraulic system and gear. This rejects the assumption that Leonardo da Vinci is the first man creating and using the mechanical gear and hydraulic.

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