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Abu'l–'Izz al-Jazari and His Role in The Advancement of the Science of Mechanics (1136-1206)

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Abstract.

Abu'l-'Izz al-Jazari is considered one of the pioneers of mechanical engineering in the middle Islamic centuries. He is known not only as a collector of previous scientists' thoughts but also as an inventor and a mechanical engineering designer.Writing about this scientist is of special significance because it basically explains an important and neglected aspect of mechanical science. This study aims to shed light on al-Jazari's efforts in the field of mechanics based on the documents and resources of Islamic history as well as foreign resources.

Abstrak

Abu'l-'Izz al-Jazari dianggap sebagai salah satu pelopor teknik mesin di abad pertengahan Islam. Ia dikenal tidak hanya sebagai pengumpul pemikiran para ilmuwan sebelumnya, tetapi juga sebagai penemu dan perancang teknik mesin. Tulisan tentang ilmuwan ini memiliki makna khusus karena pada dasarnya menjelaskan aspek ilmu mekanik yang penting dan terabaikan. Kajian ini bertujuan

untuk mengungkap kiprah al-Jazari di bidang mekanika berdasarkan dokumen dan sumber sejarah Islam serta sumber asing.

Keywords**:** *Abu'l-'Izz al-Jazari, Science of Mechanical Engineering, Islamic History and civilization*.

A. Introduction

This study addresses Abu'l-'Izz al-Jazari because this scholar's character has never been recognized as he deserves. Therefore, this research aims to introduce this personality in more detail by browsing the pages of his life and his activities in mechanical science.

This research uncovers the hidden parts of this writer's life, referring to the civilizational dimensions of this era. A descriptive method was used in this research; however, now and then, an analytical method has also been adopted. Moreover, sometimes an assessment has been made in this era and tools have been used to depict a clearer picture of al-Jazari's life and works. There were problems in conducting this study, one of which was the lack of resources in this area. The reasons for the lack of adequate resources about this character are due to his unknownness in his time. Among the sources of al-tarajim and al-wafyat, such as:

The books (tarikh al-islam wa wafayat al-mashahir wal-aelam) of Zahabi and the book (aleabar khayr min ghabr) of Zahabi and (dhayl murat alzaman) of Qutbuddin Al-Aunini and (Al-Ruzatiin and Akhbar al-Dawtain Al-Nuraiya and Salahiya) by Al-Maqdis. As for Haji Khalifa's book Kashf al-Znoon, it only mentions the name of the book and does not mention any aspect of this scholar's life. Therefore, we can say that it has been more focused and recognized by the West, after 1931 when one of his manuscripts was discovered in the United States.

For this research, We have used several different sources, including: The manuscript of Al-Jazeera's book, which We were able to obtain three different copies. With Dr. Donald Hill's 1974

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translation of the book, which further explains the book. With new sources including (1001 inventions) by Dr. Salim Al-Hassani and (Distinguished Figures in Mechanism and Machine Science) by Marco Chiccarelli . With several other sources, We have used for the events of that time in Diyarbakır, including: (Al-Kamil fi al-Tarikh) by Ibn Athir and (majmae aladab fi muejam al'asma' ealaa muejam al'alqab) by Ibn Futi and several other sources. We have used Georgian's Ta'rifat and Ibn Manzur's Lisan al-Arab to introduce the concepts and terms.

In conclusion, we hope that we have been able to contribute to scientific literature in general and especially the introduction of Al-jazari's life and innovations.

B. Al-Jazari and his era

1. His name and descent

His full name was Bedî'Az-Zamân Abû 'l-'Izz ibn Ismâ'il ibn ar-Razzâz Al-Jazarî[1], and the title "Bedî'Az-Zamân" (inventor of the era) indicates that he was a master and inventor in engineering, especially in the field of mechanical science. Furthermore, Al-Razzaz (rice seller) is reportedly derived from Al-Raz (rice), and as Sarton writes, "This title was attributed to him because he was the son of a great rice merchant during the reign of Hamdanids."[2] It is most likely due to the fact that in the regions of Amed and Hasankeyf, it was customary to add a person's title and profession to his name, and of course, in most cases, it was also referred to as the family name of the entire family of a person, especially during the time of (Artuqid dynasty) 1098-1232, when the region was famous for the existence of various jobs, including the art of bookbinding, architecture, and blacksmithing. (Al-Hamawi, 1977, 2/138).

His father reportedly was not with his son's migration to Diyarbakir and he wanted his son to plant rice together with other family members. However, his grandfather insisted that he pursue his

[1] Al-Jazari, 2016, p1, Original Book
[2] Sarton, 1937, Vol.II/p.632

interests to achieve his expectations (Yazid and Salleh, 2018, 4). The title "Al-Jazari" was also due to the fact that he migrated from the Cizre Butan region to Diyarbakir, which was known as Jazīrat Ibn ʿUmar (Al-Jazari, 1974 :3), which was his birthplace and the place he grew up. He later migrated to Diyarbakir and lived there and went through stages of progress (Ceccarelli, 2009: 1-2). These statements prove his Kurdish descent since, during that period, Cizîra was a part of the Sham at region, and today it is considered the south eastern part of Turkey (Al-Hassani, 2006: 42), which is actually the northern part of Greater Kurdistan.

2. Al-Jazari's birth and his efforts to acquire knowledge

Al-Jazari was born in 1136 in the Cizre region and died in 1206 in Diyarbakir (Al-Jazari, 1974:3). There is no information about his family and his growth and mostly his works have been considered important. According to the introduction of his book, he has been a religious person praying and worshipping God and he always began his work in the name of God and asking for God's blessing for the Prophet of Islam and praising the existence of Islam.P

Then he addresses the science of mechanics and writes, "I studied the books of other scientists and assessed their works and productions such as air tools and water tools and sundials. I also checked the quality of their constituent parts and thought about how to make them in other ways. After some investigation, effort and study, I became an expert in this field and studied the works of my predecessors and pursued this knowledge to discover the truth" (Al-Jazari, Original Book: 2-3). This shows the efforts of his predecessors in mechanics and also the scientific progress of the Diyarbakir region. Therefore, it is better to understand the reason why he left his hometown and moved to Diyarbakir. He actually settled in Diyarbakir with the aim of improving his knowledge in mechanics, although there were excellent schools in the Cizîra (Aziz, 2019: 289).

However, the Diyarbakir region at that time was a very developed and advanced place. For example, Ibn al-Athir (1987. vol.9/p. 471) writes about the events in 1184 when the city of Amed

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was captured, “In one of the captured places, thousands of books and different sources and valuable and rare tools were found”. This is evidence of the emphasis given by Artuqids to scientific issues and at the same time indicates that they were seeking and keeping scarce resources; therefore, the abundance of scientists and scientific resources may have been due to the support and encouragement of the rulers at that time (Aboosh, 2004: 158). For this reason, when a person like Al-Jazari goes there, they employ him and put him in charge of this field of knowledge (Ceccarelli, 2009: 2).

3. Al-Jazari and rulers of Diyarbakir[3]

In the introduction of his book, “Al-Jami' Bain Al-'Ilm wal-Amal Al-Nafi' fi Sina'at Al-Hiyal” (A Compendium on the Theory and Practice of the Mechanical Arts), Aljazari states, “I have written this book for his excellency Amir Naser al-Din Abi al-Fath Mahmud ibn Muhammad ibn Qar Arslan, the king of Diyarbakir” (Al-Jazari, Original Book: 3)

Al-Jazari joined this family in 579 AH/1184 AD on the eve of Saladin's arrival in Amed (Al-Jazari, 1974, p4). In that year, the emir of the city submitted to the demands of the Ayyubids to read speeches on their behalf, to issue coins and to be ready for any assistance (Ibn al-Athir, 1987, vol. 9/p. 579). For 25 years, Al-Jazari was in the court of the Ortoghis and besides Amir Naser Al-Din, he also served his father and brother (Al-Jazari, Original Book: 3) to provide cultural services and development in the region(Ali and Ahmad, 2021), (Khalil, 1980: 461). Even someone like Amir Naser Al-Din said to Al-Jazari, “You have made a large number of rare tools and also put into operation your genuine ideas, Hence, do not feel tired since I ask you to write me a book about the tools you have invented. In your book introduce all of them independently” (Al-Hassani, 2003: 42).

One of these tourists who visited Czire during this period is Ibn Jubayr, who traveled to the region in 1184 and prepared a report on the security of the city, and he also mentioned some bands of

[3] See the Table of Diyarbakir Rulers in the Appendix

Kurdish bandits that caused disturbances for the rulers there" (Ibn Jubayr, 2007: 217). In light of this security in the region, it is clear that in a city like Amed during this period, i.e., in the thirteenth century, the names of more than 200 scholars are mentioned, each of whom specialized in a field of knowledge (Al-Rashidi, 2008:193-194). This shows the prominence and great competence of the emirs of the region (Ali, 2021), who managed to be the pioneers of the development of social and constructional services in the region despite facing the Crusaders and fighting them to force them to get away from the region (Mutlaq, 1993, p. 102).

C. Al-Jazari and his contributions to mechanics

1. Al-Jazari and Mechanics

In Islamic civilization, mechanics is of special importance because this science is characterized by its peculiar, wonderful issues that are worth considering. Specialists in this field have introduced mechanics as the science of trickery and a part of engineering knowledge (Haji Khalifa, 1992, vol. 1: 148).

While examining and discussing the word "Al-hiyal" meaning trickery, Al-Jurjani writes, "This word means deceiving people about something they hate in order to present it as attractive and pleasant to them" (2006: 100). Ibn Manzur, To elaborate on the meaning of "Al-hiyal" he writes, "All these should be seen as beautiful and charming, since all the ability lies in movement, in other words, a deceptive person should be able to gather all his work in one tool thus attracting the attention of others" (1993, vol. 4: 291). Accordingly, it becomes clear to us that this knowledge is regarded as operational knowledge (Hill, 2004, p. 90). That is why Al-Jazari, chooses the title "The Theory and Practice of the Mechanical Arts" in order to be absolved of these accusations.

Different classifications have been proposed for the science of mechanics. Al-Khwarizmi classifies this knowledge into two parts: The first part includes tools for absorbing and accentuating and applying them using little force. The second part includes tools that move water and are called wonderful tools, and they are generally

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moving tools and often are called water stealers (Al-Khwarizmi, 1938: 142-143).

That was exactly of Musa ibn Shakir and his sons did in Baghdad during the Caliphate of Mamun (198-218K/813-833Z), i.e., they tried to access and acquire information from Rome in the fields of engineering and mechanics to make things move (Ibn al-Nadim, 2013: 331) and later they collected it in a book called "Al-Hiyal" (The Tricks) which included a hundred inventions. Some of these tools were simulating living things, for example, they invented a fish that, after it stopped drinking water, made a sound, which was a sign that it was full! (Al-Shannan, 2018, p.48).

Based on the available history of spreading this knowledge from Greece and Rome to the Abbasid era (Ahmad and Ali, 2022), as well as the contributions of Musa's ibn Shakir, Farabi (872- 950), al-Biruni (1048-973), and Ibn Sina (1037-980) to mechanics, Al-Jazari, made this science be introduced and appear as a different form of knowledge (Hill, 2004: 137-138) because this mechanical engineer was looking for an example to follow to improve his work. In addition to being a painter, he also had considerable expertise in engineering and mechanics (Al-Hassani, 2003: 121). That is why his inventions and knowledge are kept in the memory of experts and they remember him and his inventions with pride (Faraj, 2022).

2. Al-Jazari and His Book in the Field of Mechanics

Only one of Al-Jazari's works is available now, namely the book "Al-Jami' Bain Al-'Ilm wal-Amal Al-Nafi' fi Sina'at Al-Hiyal" (A Compendium on the Theory and Practice of the Mechanical Arts) which is known as "Kitab Fi Ma'rifat al-Hiyal al-Handasiyya" (The Book of Knowledge of Ingenious Mechanical Devices). Although Haji Khalifa mentioned two other books by this scholar in his book, i.e., "Mukhtasar Levian" and "Kitab Mabsut" (Haji Khalifa, 1992, Vol. 1: 148). However, these works are not mentioned in any other source, and It may be that this scientist had other works and disappeared, or that the same work was called by different names,

because the name of Al-Jazari's book is not mentioned in the books on instruments and mechanics.

Al-Jazari completed his book in 1204 or 1206, and during the era of Amir Naser al-Din, this book was considered one of the most significant books on mechanical science, and as Sarton writes, "This book is considered a rare and unique work among the achievements of Islamic civilization" (Sarton, 1937, Vol. II: 630).

With the aid of scholars in Islamic civilization and the mechanical science of the Islamic civilization era, Al-Jazari's book was translated into English for the first time by Dr. Donald R. Hill (1974) using copies of available manuscripts in various museums (Al-Jazari, 1974: 10-11). Although after this translation, some of Da Vinci's inventions and innovations were doubted and questioned, such as the robot and the interconnected moving body, which were attributed to Da Vinci, even though, Al-Jazari had made constructed them 200 years before Da Vinci. Perhaps, because this book was written in Arabic, the Europeans did not pay much attention to it. However, after the translation of this work into English, a number of scholars investigated the issue and concluded that Da Vinci may have been influenced by Al-Jazari (Faraj, 2022).

It is worth mentioning that Da Vinci has been in correspondence with officials in the Ottoman Empire. In 1502 and during the period of Sultan Bayezid II (1481-1512) he designed a 220-meter bridge for the Ottoman sultans. Therefore, Da Vinci may have accessed Al-Jazari's book. Another point to mention is that a copy of this book is still kept in Istanbul Museum (Yazid and Salleh, 2018: 5).

Of course, other copies of this Al-Jazari book are kept in other places. For example, a copy whose date goes back to the year (1354) is kept in the Hagia Sophia museum in Istanbul. According to the investigations, this version is considered the original version. Moreover, there is a copy in the Bodleian Library in Oxford, and in 1920, another copy of this version was presented in New York, which

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dates back to the end of Ramadan 1315; therefore, this copy has been prepared 39 years earlier than the Istanbul copy. This version has been revised by the writer Farooq Abdul Latif (Oglu, 1931: 27).

Al-Jazari's book consists of the following chapters: Introduction, design, and the way 50 mechanical engineering tools operate. As the Italian orientalist Dumilli says, “Al-Jazari's book is the best book about the development process of this science from ancient Greece to the era of Islamic civilization” (Al-Sabbagh, 1998: 217). Of course, this scholar has talked about other tools that were more royal and aristocratic, in other words, they were necessary for governance, and he has collected them in six chapters:

- Water and candle clocks (10 chapters)
- Special tools suitable for drinking meetings (10 chapters)
- Ablution tools (10 chapters)
- Fountains with the sound of a flute that sometimes change their sound (10 chapters)
- Tools for water transfer (5 chapters)
- Miscellaneous tools (5 chapters) (Al-Jazari, 2017: pp.515-527)

3. Al-Jazari inventions in the science of mechanics

In his book, along with the introduction of several mechanical tools, Al-Jazari has been able to depict the image of all these tools with the highest artistic vertu in such a way that it can be used as a textbook. In other words, apart from the fact that this book is a book in the field of mechanics, it contains a number of his other inventions, among which the following can be mentioned:

a. Human-robots

One of the tools that have been widely used in Al-Jazari's works is a human robot. That is why he is known as the father of robotics in mechanical science (Yazid and Salleh, 2018: 5). Of course, robotic animals have been discussed before him in the works

of Musa's sons, but Al-Jazari's work is different because his tools are mobile, and on the other hand, he managed to use several robots in one instrument, for example, a musical band on top of the ship, which was made of eleven robots, and each of these robots poured water into each other's jug, and finally, the wine was presented to the last robot on top of the ship, which was the biggest of all and was dressed as a king. In the same ship, four robots were making musical sounds (Al-Jazari, 2017: pp.312-315). Furthermore, the hanging clock was among the tools that used a wonderful robot in which five robots were used (Al-Jazari, 2017: pp.124-125). See Figure 2.

Another tool in which a robot was used was the elephant water clock which is considered one of Al-Jazari's water clocks. This clock is a product of the inventions of different civilizations, and among these, we can mention the water foundations of Greek Archimedes, the comparative tool of Indian water (Gati), and the image of an elephant, which is a symbol and indication of India. Simorgh is a symbol of ancient Egypt. Three Robots with turbans refer to Islamic civilization and it also has Iranian symbols and Chinese dragons.

It is widely generally believed that the man with a turban sitting on the top of the castle is Sultan Salah al-Din Ayyubi. By relying on the role of different civilizations in the development of tools, Al-Jazari was able to make this wonderful and thoughtful clock, and the measuring instrument of this watch was a bucket of water with holes, which gradually sank (al-Hassani, 2006: 44-45 & Al-Jazari, 1974: 62-63). For more information, see Figure 3.

b. Hand washing tools

Another tool invented and made by Al-Jazari is the ablution tool. This tool is very complex and much more artistic and attractive than today's washing tools (al-Hassani, 2006: 50). This tool was mobile and prepared for guests at parties. A part of this device was made in the shape of a peacock, with water pouring out of the peacock's mouth. When the guest touched the peacock's head eight

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times, water came out of the peacock's mouth, which was enough to perform ablution (Al-Jazari, 2017: pp.362-365). See Appendix No. (4)

Some of these other tools were human robots that had towels for guests (See Figure 5). Moreover, he made another set of tools, most of which were robots, and they served drinks like juice and water in different ways. (Oglu, 1931: 28)

c. Water storage tools

Al-Jazari invented an amazing water storage device that raised a considerable amount of water without the need to use manpower. Hence, he was the first person to use a moving system of gears and a connected cylinder. This is defined as one of the important innovations of mechanical science because it was rotational motion (Ceccarelli, 2009: 1). In this rotation, the toothed moving parts are used in every type of tool, from children's toys to important mechanical tools such as mobile machines (Al-Hassani, 2006: 50). For more information, see Figure 6.

d. Coded chest

For the first time in his book, Al-Jazari explained how to lock and then open a chest without using a key. He believed in a new and different key to open and lock a chest differently, and in this case, a long tool could be moved at the right time by dividing twelve letters by four circles. Therefore, the lock could be opened only when the key was placed in the right place by entering the letters that could unlock the chest and the letters were previously programmed to open the chest (Al-Jazari, 1974: 199-200). See Figure 7.

D. Conclusion

Al-Jazari was a prominent scholar of Kurdish origin in the middle centuries who lived during the Artuqid dynasty. During twenty-five years of service to the rulers of the time, he earned the prominent position of “the Engineer”. Due to his special expertise and capability in the field of mechanics, he was respected by the rulers of the time until finally he was asked by Amir Naser al-Din to write a

book for him. His book, Al-Jami', is considered a prominent and influential source, and he is remembered as the motivator of the industrial revolution because Al-Jazari is known as the inventor of turning rotational motion into vertical motion through a handle and medium. According to experts in the field of history of science and orientalists, Al-Jazari's books are rare books from the middle centuries. Apart from his expertise in the field of mechanics, Al-Jazari has had several ideas and designed various inventions, to name but a few the following can be mentioned: a robot man, a hand washing tool, a water storage tool, and determining a code for a chest. This scholar's inventions and activities are still a source of reflection and require further research by experts in this field.

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Appendix

The following pictures are taken from the book version of the Bodleian Museum.

Figure 1.

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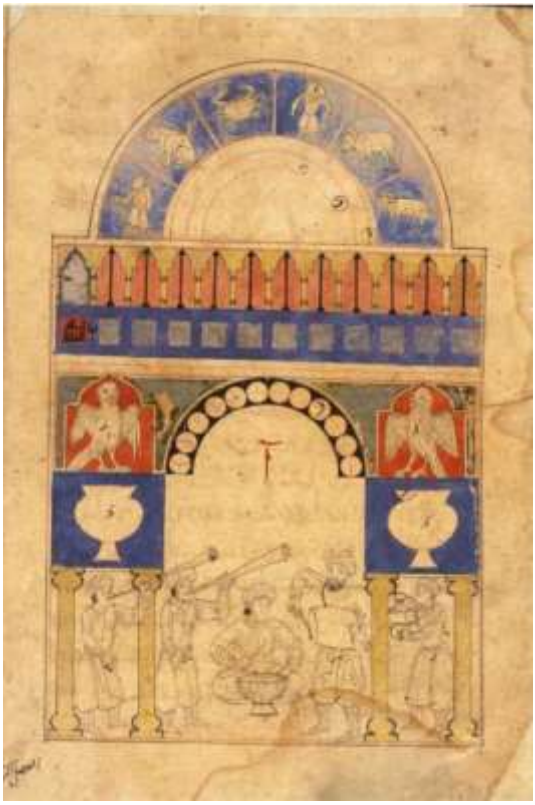

Figure 2.

Figure 3

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Figure 4

Figure 5

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Figure 6

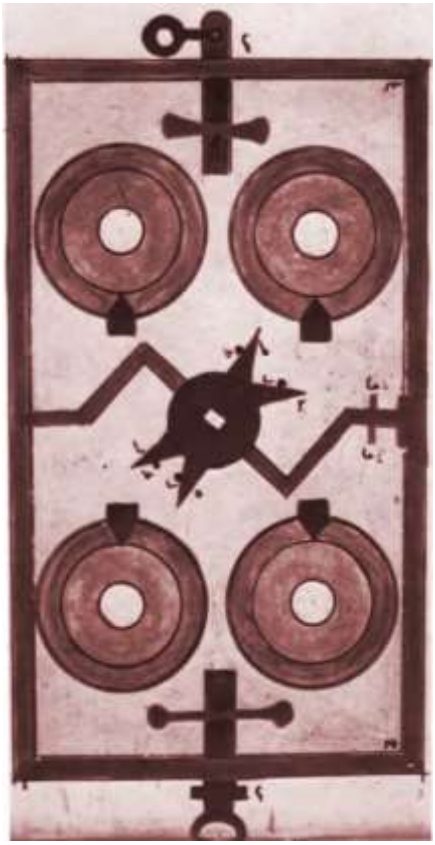

Figure 7

Table. The rulers of Diyarbakir in the Al-Jazari era

No	Artuq rulers in Diyarbakir	Ruling Period
1	Nooruddin Mohammad (Mohammed bin Qara Arslan Nooruddin)	570-581K/1174-1185AD
2	Qutb al-Din (Suqman bin Muhammad Qutb al-Din)	581-597K/1185-1200 AD
3	Naser al-Din (Mahmoud bin Muhammad Naser al-Din)	597-619K/1200-1222 AD

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