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THE GENESIS OF ENGINEERING KNOWLEDGE IN THE VIEWS OF EASTERN THINKERS IN THE MIDDLE AGES

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Abstract

This article examines the renaissance in engineering and exact sciences in the medieval Eastern world. Using the example of Al-Khwarizmi, Ibn Sina, Al-Basari, Beruni, and Alkhazen, we can study how engineering knowledge based on experimental natural science developed in the East. We can consider that inventions and engineering achievements brought to Europe by the East, such as mechanical clocks, compasses, gunpowder, paper, played a huge role in the development of European civilization.

Keywords: Optics, "Houses of Wisdom," earth meridian, cylinder, "impetus," "conical device.

Introduction

The peculiar culture of the caliphate period, which rapidly strengthened in the countries of the Muslim East from the 7th century onwards, continued on the basis of the traditions of scientific thought of the Middle East and the Hellenistic period. The achievements of scientists and engineers of the Hellenistic period contributed to the further development of medicine, astronomy, and mathematics. Manuscripts of Aristotle, Euclid, Archimedes, and others, translated from Ancient Greek into Persian and Arabic, later served as a source for translating

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into Latin. Also, Eastern scholars translated the works of Greek philosophers and wrote commentaries on them. For example, Abu Nasr Farabi's works on the works of Aristotle were well-known and famous. Many works of ancient mechanics have survived to this day only in Arabic. According to V. Gorokhov, in the Middle Ages, the works of scholars and translations of ancient authors from the countries of the Muslim East reached Europe through the Caliphate of Spain (Cordoba), Sicily, and Byzantium.

The reign of Caliph Harun al-Rashid (763 or 766 - 809) marked the beginning of the first comprehensive renaissance in the Muslim Eastern world. The emergence of this renaissance was influenced by other cultures. Important relations have been established with India and China. By the end of the 9th century, Baghdad, the capital of the Caliphate, became a center of science and enlightenment in the world. Here, under the special patronage of the Caliph, the "House of Wisdom" was opened. A large group of scholars, translators, and calligraphers was engaged in translating scientific treatises from Greek and Syriac into Arabic. In the initial stages, most of the translations were carried out by foreign scholars. Caliph Harun al-Rashid actively supported scholars who not only studied Greek but also translated Greek philosophical and scientific works. He sent people to the West to buy Greek manuscripts. It is known that since most scientific works of this period were written in Arabic, Eastern science is usually called Arabic science. In particular, the 9th-11th centuries marked the flourishing of science in the Muslim East. By this time, public libraries, particularly "Houses of Wisdom" and educational institutions in Khwarazm, had opened in Baghdad, Cairo, Damascus, Ray, Gurganj (Urgench), Bukhara, Ghazni, Samarkand, and other cities.

Abu Abdullah Muhammad ibn Musa al-Khwarizmi (783-850), who lived during the reign of the enlightened Caliph al-Ma'mun, is the author of numerous works on arithmetic and algebra. Al-Khwarizmi's algebraic treatise became the basis for the emergence of a new branch of mathematics - algebra ("Al-Jabar"). It would be more accurate to say that Muhammad bin Musa al-Khwarizmi laid the

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foundation for the science of algebra. Around 830, he wrote the first Arabic treatise on algebra. In the works of Al-Khwarizmi, algebra emerged as an independent science. In Khorezmi's treatises, linear and quadratic equations are solved. His book "On the Processes of Restoration and Reduction," which was also popular in Europe in the 12th century, gave the name to the new science (al-Jabr - restoration). The term algorithm also comes from the name of al-Khwarizmi. It must be admitted that this knowledge of al-Khwarizmi had a great influence on the development of engineering knowledge in the world in subsequent periods. There is little information about the scientist's life, but there is information that he participated in measuring the length of one degree of the Earth's meridian on the Sinjar plain in 827 and led an expedition to the land of the Khazars in 847 during the reign of Caliph al-Wasiq.

In the 12th century, translations of treatises by Khwarizmi and other Eastern authors began to appear in Europe. Copernicus and Galileo influenced the beginning of the scientific revolution. New numeration, algebra, and trigonometry were not only mastered, but also improved by European scientists. Arabic translations of the works of Aristotle and Ptolemy also began to be taught in the departments of medieval European universities.

Naturally, the development of mathematics and geometry in the countries of the East served as the basis for the development of engineering knowledge. After all, it is impossible to imagine engineering activity without calculations and measurements. During this period, the development of engineering mechanics began with the creation of the theory of "impetus" (Greek: *impetus*, impulse) - the "driving force." The foundations of this theory were laid by the Alexandrian scholar John Philoponus (c. 490-570). At first glance, the impulse seems to be an analogue of the body's momentum. But in reality, this is not a vector quantity, but a scalar quantity, and the theory of momentum is an attempt to reconcile Aristotle's explanation of the causes of mechanical motion with practice. The study of mechanics in Islamic countries began with the translations and

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commentaries of ancient authors - Aristotle, Archimedes, and Heron, and later followed the same directions. In the works of Ibn Sina and Beruni, the theory of "impetus" is further developed.

According to Ibn Sina, "natural" and "forced desire" cannot coexist simultaneously. The body moves under the influence of the "forced desire" until it is tired of the influence of the external environment. After this, it immediately stops for a moment and, under the influence of "natural desire," begins to move, i.e., the vertical descends. Thus, according to Ibn Sina's theory, at one point in the trajectory of a thrown object, gravity does not act on it. It can be said that this theory played an important role in the engineering activities of that and subsequent periods.

However, long before the Renaissance in the Muslim East, the achievements of ancient science were also known in the Transcaucasian countries. Armenia and Georgia already in the 4th century established close economic and cultural ties with Byzantium. Christianity entered these countries long before Russia, and in 301 Christianity became the state religion in Armenia, the ideological support of early feudalism. In the 5th-7th centuries, the works of Aristotle, Plato, and other scholars were translated into Armenian. The famous Armenian scholar of the early 7th century, Anania Shirakatsi, traveled to Byzantium. Shirakatsi studied mathematics and philosophy there and returned to his homeland to establish a school where mathematics, astronomy, and geography were taught. He was the first to compile an Armenian arithmetic textbook and publish a treatise on cosmography. This testifies to Shirakatsi's deep knowledge of the works of the Greek scholar Aristotle.

In his work, Shirakatsi also addressed purely astronomical issues: he attempted to predict distances to the Sun and Moon, and compiled a calendar. This indicates that he observed the movements of the Sun and Moon and was well-versed in the works of ancient scientists on this topic. This information indicates that Shirakatsi also engaged in engineering activities.

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Shirakatsi was a versatile scholar who linked young Armenian science with an ancient heritage. Unfortunately, the role of Caucasian scientists in the development of scientific knowledge and ancient heritage has not been sufficiently studied. As can be seen from the example of Shirakatsiy, the scholars of Transcaucasia managed to assimilate ancient knowledge directly from the original source, from the Greeks themselves.

Of course, the scale of scientific and educational development in the Muslim East was much broader. During this period, scientists began to develop experimental, i.e., experience-based science, which had a priority significance in the formation of engineering activity. In particular, our compatriot scholar Abu Rayhan Beruni determined the density of metals and other substances using his "conical device." Beruni's "conical structure" was like a vessel that narrowed upward and ended with a cylindrical "neck." A small round hole is made in the middle of the neck, to which a curved tube of the corresponding size is glued. Water is poured into the vessel. Pieces of metal, the density of which was being determined, were lowered into a container with water through a curved pipe equal to the volume of the metal being studied. The "neck" was quite narrow (as wide as a small finger). The rise of water was noticeable even when changing the weight equal to the volume of a millet grain. After a series of experiments, the pipe itself was replaced with a new one. Then water flows through it, and the density of the metal or substance is determined. According to Beruni's measurements, the density of gold converted to modern units of measurement was 19.5 and mercury was 13.56.

Al-Biruni observed and described the change in the Moon's color during a lunar eclipse and the phenomenon of the solar corona during a total solar eclipse. He put forward the idea of the Earth's rotation around the Sun and considered the geocentric theory very weak. He wrote a comprehensive work about India and translated Euclid's "Elements" and Ptolemy's "Almagest" into Sanskrit.

Beruni's circle of interests was very wide. Mathematics, chronology, astronomy, geography, geology, geodesy, astronomy, physics, botany, mineralogy,

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ethnography, history. In astronomy, along with the geocentric system, Beruni also recognized the heliocentric system. To solve cubic equations, Beruni used the test method. His thirst for knowledge appeared very early, and even in his youth, he was closely connected with the scientific circles of ancient Khorezm. According to his testimony, at the age of 21-22, he "made astronomical measurements using a circle with a diameter of 15 cubits and other tools necessary for this." At this time, a coup d'état took place in Khorezm, and he was forced to leave Khorezm after living in a foreign land for about ten years. This negatively affected Beruni's fate. Upon his return, Beruni became one of the statesmen of Khorezm. During these years, he conducted measurements of the density of metals and precious stones. At the same time, he began extensive correspondence with another famous scientist who worked in Khwarazm, Ibn Sina (Avicenna, 980-1037), with whom he discussed a number of issues of natural science and Aristotelian physics. While Beruni sharply criticized many of Aristotle's ideas, Ibn Sina played the role of Aristotle's defender.

In 1017, Mahmud of Ghazni, the ruler of Khorasan and Afghanistan, conquered Khwarazm, and Beruni was sent to Ghazni along with other prisoners. Despite the difficult conditions, Beruni continued his scientific activity, completing a number of works on geography and astronomy, including the famous work "India." When Mahmud's son Mas'ud ascended to the throne, he paid attention to Beruni and patronized him. The scholar dedicated his major work on astronomy and spherical trigonometry to Mas'ud and named it "Qanun al-Mas'udi." He also wrote "Mineralogy" and "Book of Medicines." Beruni died on December 13, 1048. The renowned Russian orientalist scholar I.Yu. Krachkovsky emphasized that Beruni was an encyclopedic scholar who equally covered all fields of modern sciences, especially the natural history of mathematics and physics.

Another scientist who made a great contribution to the development of engineering knowledge, Beruni's contemporary, the Egyptian Abu Ali Hasan al-Haysan al-Basri (965-1039), known in Europe as Alhazen, occupies a special

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place. His main research is focused on the field of optics. By conducting his experiments and building devices for them, Alhazen developed the scientific heritage of his predecessors. He developed the theory of vision. Alhazen described the anatomical structure of the eye and determined that the eyes are image receivers. Unfortunately, despite Alhazen's innovation, until the 17th century, the idea of the image appearing on the retina dominated. His main work on optics, "Treasury of Optics," was in many respects an achievement in this field. Al-Basri achieved great success in the study of lenses, spherical and parabolic mirrors. In addition, he was an outstanding representative of the experimental approach to the study of optical phenomena and for his time precisely analyzed the structure and function of the eye. Unlike Aristotle, he concluded that light comes not from the eye, but from the observed object. Al-Basri also wrote a commentary on Euclidean elements. In general, al-Basri is considered the greatest physicist of the Eastern world. He had a strong influence on Western science, including Roger Bacon, Kepler, and Newton.

It is worth noting that Alhazen is the first scientist to know the work of the camera obscura to be used as an astronomical device for obtaining images of the sun and moon. Alhazen considered the uniform, spherical, cylindrical, and conical motion of light. He posed the problem of determining the reflection point of a cylindrical mirror based on the given positions of the light source and the eye. Mathematically, the Alhazen problem is constructed as follows: two external points and a circle located in the same plane are given. It is necessary to determine such a point on the circle that the lines connecting it with the given points form equal angles with the radius drawn to the desired point. This problem is equivalent to a quadratic equation. Alhazen solved this geometrically. Later, the Alhazen problem was solved by such great scientists as Barrow, who was the mentor of Huygens and Newton in the 17th century.

We would not be wrong to say that Alhazen was one of the first engineers who laid the foundation for optical engineering. He studied the refraction of light.

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Alhazen developed a method for measuring angles of refraction and experimentally demonstrated that the angle of refraction is not proportional to the angle of incidence. Although Alhazen did not find an exact formula for the law of refraction, he significantly supplemented Ptolemy's results, finding that the incident and refracted rays lie in the same plane as the perpendicular erected from the point of incidence of the ray. Alhazen understood the magnification effect of a plano-convex lens, the concept of the viewing angle, and its dependence on the distance to the object. By studying the duration of light falling, he also attempted to calculate the height of the atmosphere. According to his assumptions, the height of the atmosphere was 52,000 paces. But Alhazen's own attempts are a great achievement of medieval optics. Alhazen's "Book of Optics" was translated into Latin in the 12th century. However, many considered this book a copy of Ptolemy's work. Only after the discovery and publication of Ptolemy's work did it become known that Alhazen's optics was an original work developing the achievements of ancient scientists.

In conclusion, using the example of Beruni and Alhazen, we can study how engineering knowledge based on experimental natural science developed in the East. The inventions and engineering achievements brought to Europe by the East, such as mechanical clocks, compasses, gunpowder, and paper, played a huge role in the development of European civilization. The development of engineering knowledge in the Middle Ages also took place in other regions of the East. For example, the engineering of paper and printing type was first developed in China. It is known that paper appeared in Europe in the 11th-12th centuries. However, paper was invented by the Chinese Chay Lun in the 2nd century, and a unique paper production process was formed. Printed plate printing also first appeared in China in the 9th century AD. Printed in this way was called an engraving. The relief on the board is covered with paint. Then a sheet of paper was printed on it. In the 11th century, the Chinese blacksmith Bi-Shen (Pi-shen) made letters from clay and systematized them. Thus, he was the first in the world

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to use moving letters. By the 13th century, bronze letters were introduced in Korea instead of clay letters.

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