Chinese contributions to engineering

Science, engineering and technology

Engineering is the goal-oriented process of designing and making tools and systems to exploit natural phenomena for practical human means, often (but not always) using results and techniques from science. The development of technology may draw upon many fields of knowledge, including scientific, engineering, mathematical, linguistic, and historical knowledge, to achieve some practical result.

The distinction between science, engineering and technology is not always clear. Science is the reasoned investigation or study of phenomena, aimed at discovering enduring principles among elements of the phenomenal world by employing formal techniques such as the scientific method.[13]

Technology is often a consequence of science and engineering – although technology as a human activity precedes the two fields. For example, science might study the flow of electrons in electrical conductors, by using already-existing tools and knowledge. This new-found knowledge may then be used by engineers to create new tools and machines, such as semiconductors, computers, and other forms of advanced technology.

Technologies significantly affect human as well as other animal species' ability to control and adapt to their natural environments. The human species' use of technology began with the conversion of natural resources into simple tools. The pre-historical discovery of the ability to control fire increased the available sources of food and the invention of the wheel helped humans in travelling in and controlling their environment. Recent technological developments, including the printing press, the telephone, and

the Internet, have lessened physical barriers to communication and allowed humans to interact freely on a global scale. However, not all technology has been used for peaceful purposes; the development of weapons of ever-increasing destructive power has progressed throughout history, from clubs to nuclear weapons.

With this consideration, scientists and engineers may both be considered as technologists; the three fields are often considered as one for the purposes of research and reference.[14] By this statement, the consideration s of the word engineering may be used along with the word technology and science as appropriate in this paper.

The contributions of Chinese to engineering are not in doubt. Some of the major contributions would include the compass, gunpowder, papermaking, and printing, which were among the most important technological advances, only known in Europe by the end of the Middle Ages.

Most of the materials invented by the Chinese were produced into useful engineering resources then and today to improve the environment and for the use of man on earth.

This paper will examine the contributions of the Chinese to engineering through the historic research and to confirm whether such contributions are relevant to global development.

History of Science and Technology in China

The history of engineering in China is both long and rich with many contributions to engineering technology. Ancient Chinese philosophers made significant advances in science, technology, engineering, mathematics, and

astronomy. The first recorded observations of comets, solar eclipses, and supernovae were made in China.[1] Traditional Chinese medicine, acupuncture and herbal medicine were similarly practiced.

Among the earliest inventions were the abacus, the “ shadow clock,” and the first flying machines such as kites and Kongming lanterns.[2] The four Great Inventions of ancient China: the compass, gunpowder, papermaking, and printing, were among the most important technological advances, only known in Europe by the end of the Middle Ages. In the 16th and 17th centuries, western science and astronomy, had its own revolution, and knowledge of Chinese technology was brought to Europe.[3][4]. Much of the early Western work in the history of science in China was done by Joseph Needham.

Early technological achievements

Medicine

The understanding derived from Taoist philosophy, one of the newest longstanding contributions of the ancient Chinese are in Traditional Chinese medicine, including acupuncture and herbal medicine. The practice of acupuncture can be traced back as far as the 1st millennium BC and some scientists believe that there is evidence that practices similar to acupuncture were used in Eurasia during the early Bronze Age.[10]

Counting and time-keeping devices

The ancient Chinese also invented counting and time-keeping devices, which facilitated mathematical and astronomical observations. Shadow clocks, the forerunners of the sundial, first appeared in China about 4, 000 years ago,[2]

while the abacus was invented in China sometime between 1000 BC and 500 BC.[11][12] Using these the Chinese were able to record observations, documenting the first recorded solar eclipse in 2137 BC, and making the first recording of any planetary grouping in 500 BC.[1]

Architecture and Civil Engineering

In architecture and civil engineering, the pinnacle of Chinese technology manifested itself in the Great Wall of China, under the first Chinese Emperor Qin Shi Huang between 220 and 200 BC. The Qin Dynasty also developed the crossbow, which later became the mainstream weapon in Europe. Several remains of crossbows have been found among the soldiers of the Terracotta Army in the tomb of Qin Shi Huang.[16]

Mechanical Engineering

The Eastern Han Dynasty scholar and astronomer Zhang Heng (78-139 AD) invented the first water-powered, rotating armillary sphere (the first armillary sphere having been invented by the Greek Eratosthenes), and catalogued 2500 stars and over 100 constellations. In 132, he invented the first seismological detector, called the “ Houfeng Didong Yi” (“ Instrument for inquiring into the wind and the shaking of the earth”).[17] According to the History of Later Han Dynasty (25-220 AD), this seismograph was an urn-like instrument, which would drop one of eight balls to indicate when and in which direction an earthquake had occurred.[17] On June 13, 2005, Chinese seismologists announced that they had created a replica of the instrument.[17]

The mechanical engineer Ma Jun (c. 200-265 AD) was another impressive figure from ancient China. Ma Jun improved the design of the silk loom,[18] designed mechanical chain pumps to irrigate palatial gardens,[18] and created a large and intricate mechanical puppet theatre for Emperor Ming of Wei, which was operated by a large hidden waterwheel.[19] However, Ma Jun's most impressive invention was the South Pointing Chariot, a complex mechanical device that acted as a mechanical compass vehicle. It incorporated the use of a differential gear in order to apply equal amount of torque to wheels rotating at different speeds, a device that is found in all modern automobiles.[20]

Sliding calipers were invented in China almost 2, 000 years ago.[2] The Chinese civilization was the earliest civilization to experiment successfully with aviation, with the kite and Kongming lantern (proto Hot air balloon) being the first flying machines.

Printing, Gunpowder and the Compass

Printing, gunpowder and the compass have changed the whole face and state of things throughout the world; the first in literature, the second in warfare, the third in navigation; since then, a lot of changes have followed, in so much that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries.

Printing was recorded in China in the Tang Dynasty, although the earliest surviving examples of printed cloth patterns date to before 220.[21] Pin-pointing the development of the compass can be difficult: the magnetic attraction of a needle is attested by the Louen-heng, composed between AD

20 and 100,[22] although the first undisputed magnetized needles in Chinese literature appear in 1086.[23]

In the 7th century, book-printing was developed in China, Korea and Japan, using delicate hand-carved wooden blocks to print individual pages.[2] The 9th century Diamond Sutra is the earliest known printed document.[2] Movable type was also used in China for a time, but was abandoned because of the number of characters needed; it would not be until Johannes Gutenberg that the technique was reinvented in a suitable environment.[2]

One of the most important military treatises of all Chinese history was the Huo Long Jing written by Jiao Yu in the 14th century. For gunpowder weapons, it outlined the use of fire arrows and rockets, fire lances and firearms, land mines and naval mines, bombards and cannons, along with different compositions of gunpowder, including ‘ magic gunpowder’, ‘ poisonous gunpowder’, and ‘ blinding and burning gunpowder’ (refer to his article).

For the 11th century invention of ceramic, movable type printing by Bi Sheng (990-1051), was enhanced by the wooden movable type of Wang Zhen in 1298 and the bronze metal movable type of Hua Sui in 1490.

Among the scientific accomplishments of early China were matches, dry docks, the double-action piston pump, cast iron, the iron plough, the horse collar, the multi-tube seed drill, the wheelbarrow, the suspension bridge, the parachute, natural gas as fuel, the raised-relief map, the propeller, the sluice gate, and the pound lock. The Tang Dynasty (618 – 906 AD) in particular was a time of great innovation.[2]

In addition to gunpowder, the Chinese also developed improved delivery systems for the Byzantine weapon of Greek fire, Meng Huo You and Pen Huo Qi first used in China c. 900.[29] Chinese illustrations were more realistic than in Byzantine manuscripts,[29] and detailed accounts from 1044 recommending its use on city walls and ramparts show the brass container as fitted with a horizontal pump, and a nozzle of small diameter.[29] The records of a battle on the Yangtze near Nanjing in 975 offer an insight into the dangers of the weapon, as a change of wind direction blew the fire back onto the Song forces.[29]

The Song Dynasty (960-1279) brought a new stability for China after a century of civil war, and started a new area of modernisation by encouraging examinations and meritocracy. The first Song Emperor created political institutions that allowed a great deal of freedom of discourse and thought, which facilitated the growth of scientific advance, economic reforms, and achievements in arts and literature.[30] Trade flourished both within China and overseas, and the encouragement of technology allowed the mints at Kaifeng and Hangzhou to gradually increase in production.[30] In 1080, the mints of Emperor Shenzong were produced 5 billion coins (roughly 50 per Chinese citizen), and the first banknotes were produced in 1023.[30] These coins were so durable that they would still be in use 700 years later, in the 18th century.[30]

Astronomy and Horology

The equally talented statesman Su Song was best known for his engineering project of the Astronomical Clock Tower of Kaifeng, by 1088 AD. The clock tower was driven by a rotating waterwheel and escapement mechanism.

Crowning the top of the clock tower was the large bronze, mechanically-driven, rotating armillary sphere. In 1070, Su Song also compiled the Ben Cao Tu Jing (Illustrated Pharmacopoeia, original source material from 1058-1061 AD) with a team of scholars. This pharmaceutical treatise covered a wide range of other related subjects, including botany, zoology, mineralogy, and metallurgy.

The telescope was introduced in the 17th century. In 1669, the Peking observatory was completely redesigned and refitted under the direction of Ferdinand Verbiest in 1669. Today, China continues to be active in astronomy, with many observatories and its own space program.

Theory and hypothesis

Theory and hypothesis usually are required for sound background on inventions, this was lacking in the Chinese inventions. This was noted by Toby E. Huff, that pre-modern Chinese science developed precariously without solid scientific theory, while there was a lacking of consistent systemic treatment in comparison to modern and contemporary European works such as the Concordance and Discordant Canons by Gratian of Bologna (fl. 12th century).[44] This drawback to Chinese science was lamented even by the mathematician Yang Hui (1238-1298), who criticized earlier mathematicians such as Li Chunfeng (602-670) who were content with using methods without working out their theoretical origins or principle, stating:

The men of old changed the name of their methods from problem to problem, so that as no specific explanation was given, there is no way of telling their theoretical origin or basis.[45]

Despite this, Chinese thinkers of the Middle Ages proposed some hypotheses which are in accordance with modern principles of science. Coinciding with the astronomical work of his colleague Wei Pu, Shen and Wei realized that the old calculation technique for the mean sun was inaccurate compared to the apparent sun, since the latter was ahead of it in the accelerated phase of motion, and behind it in the retarded phase.[49] Shen also explained that the observance of a full moon occurred when the sun’s light was slanting at a certain degree and that crescent phases of the moon proved that the moon was spherical, using a metaphor of observing different angles of a silver ball with white powder thrown onto one side.[51][52] It should be noted that, although the Chinese accepted the idea of spherical-shaped heavenly bodies, the concept of a spherical earth (as opposed to a flat earth) was not accepted in Chinese thought until the works of Italian Jesuit Matteo Ricci (1552-1610) and Chinese astronomer Xu Guangqi (1562-1633) in the early 17th century.[53]

Scientific and technological stagnation

One question that has been the subject of debate among historians has been why China did not develop a scientific revolution and why Chinese technology fell behind that of Europe. Many hypotheses have been proposed ranging from the cultural to the political and economic. Nathan Sivin has argued that China indeed had a scientific revolution in the 17th century and that we are still far from understanding the scientific revolutions of the West

and China in all their political, economic and social ramifications.[103] John K. Fairbank argued that the Chinese political system was hostile to scientific progress.

Needham argued, and most scholars agreed, that cultural factors prevented these Chinese achievements from developing into what could be called “ science”.[3] It was the religious and philosophical framework of the Chinese intellectuals which made them unable to believe in the ideas of laws of nature:

CONCLUSIONS

From the on-going, it is obvious that the Chinese has made tremendous contributions to engineering, science and technology through the inventions of paper, printing, gunpowder, Astronomy and Horology, the Compass, Mechanical Engineering, Architecture and Civil Engineering, Counting and time-keeping devices, and Medicine. Most of these inventions were established before the revolution in Europe.

Each of the invention led to another development in the field of engineering. Even the invention of medicine brought about the engineering production of pharmaceutical drug production and the engineering machines required for its production.

Today, the level of engineering production and innovation by the Chinese has touched the life and the economy of many people all over the world for both poor and rich.

These contributions to engineering by the Chinese had been sustained and improved upon over the centuries. Their sense of aesthetics has made their products more attractive than other countries’. However, their production varies in standards with most of the production believed to be inferior to those of Europe that are considered of constant but of higher quality.

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