TRANSFORMAÇÃO
Revista de Filosofia da Unesp 50 anos

unesp UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
FACULDADE DE FILOSOFIA E CIÊNCIAS

Evaluation of the philosophical thought of ancient Chinese metallurgical technology culture

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HUA, Xiaofang; JIANG, Maofa. Evaluation of the philosophical thought of ancient Chinese metallurgical technology culture. *Trans/Form/Ação:* Unesp journal of philosophy, Marília, v. 47, n. 5, "Eastern thought 2", e02400158, 2024.

Abstract: Ancient China's metallurgical technology is known for its antiquity and delicacy, but, for a long time, people have always been sensitive to the philosophical ideas contained in it, lacking a rational understanding and theoretical generalization. Metallurgical technology is a typical technology in ancient Chinese craftsmanship. It provided a detailed analysis of the philosophical ideas contained in metallurgical technology, including ironmaking (steelmaking) technology and bronze smelting and casting technology. It is believed that the prominent features of ancient Chinese metallurgical technology culture are the emphasis on the importance of philosophy, the emphasis on "timing, geographical advantages, and human harmony", and the emphasis on the philosophical thought of "harmony".

Keywords: Metallurgical Technology Culture. Philosophical Thought. "Harmony" Philosophical Thought. Ancient Technology.

HUA, Xiaofang; JIANG, Maofa. Évaluation de la pensée philosophique sur l'ancienne culture chinoise de la technologie métallurgique. *Trans/form/ação:* revista de filosofia da Unesp, Marília, v. 47, n. 5, "Eastern thought 2", e02400158, 2024.

Résumé: La technologie métallurgique de la Chine ancienne est connue pour son ancienneté et sa délicatesse, mais pendant longtemps, le peuple chinois a toujours été sensible aux idées philosophiques qu'elles contiennent et le manque de compréhension rationnelle et généralisation théorique. La technologie métallurgique est une technique typique de l'ancien artisanat chinois. Cet article présente une analyse détaillée des idées philosophiques contenues dans la technologie métallurgique, notamment la technologie de la fabrication du fer (sidérurgie) et la technologie de la fonte et du moulage de bronze. Nous estimons que les principales caractéristiques de l'ancienne culture chinoise de la technologie métallurgique sont l'accent mis sur l'importance de la philosophie, l'accent mis sur "le temporel, les avantages géographiques, et l'harmonie humaine", et l'accent mis sur la pensée philosophique sur l'"harmonie".

Mots-clés: Culture de la Technologie Métallurgique. Pensée Philosophique. Pensée Philosophique "Harmonie". Technologie Ancienne.

Received: 07/09/2023 | Approved: 13/11/2023 | Published: 18/04/2024

https://doi.org/10.1590/0101-3173.2024.v47.n5.e02400158

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Abstract: Ancient China's metallurgical technology is known for its antiquity and delicacy, but, for a long time, people have always been sensitive to the philosophical ideas contained in it, lacking a rational understanding and theoretical generalization. Metallurgical technology is a typical technology in ancient Chinese craftsmanship. It provided a detailed analysis of the philosophical ideas contained in metallurgical technology, including ironmaking (steelmaking) technology and bronze smelting and casting technology. It is believed that the prominent features of ancient Chinese metallurgical technology culture are the emphasis on the importance of philosophy, the emphasis on "timing, geographical advantages, and human harmony", and the emphasis on the philosophical thought of "harmony".

Keywords: Metallurgical Technology Culture. Philosophical Thought. "Harmony" Philosophical Thought. Ancient Technology.

Introduction

By studying metallurgical technology and culture at different levels, we can better understand the human society's development history and progress process. Metallurgical technology is an important component of human civilization development, reflecting the wisdom, creativity and technological level of different cultures. Exploring different levels of metallurgical technology culture can help us gain a more comprehensive understanding of the diversity and complexity of human civilization. In archaeological metallurgy, it is necessary to conduct in-depth research on the main trends in the development of ancient technology, and metallurgical technology is usually considered as two main trends. The first is related to the type of mineral used, and the second is related to the type of metal used. These two trends

[1] This worked by the Liaoning Province Social Science Planning Fund Project "Research on the Path of Integration of Chinese Excellent Traditional Culture into Ideological and Political Education in Colleges and Universities" (Project nº L22BSZ081)

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are interrelated (Grigoriev, 2018, p. 1). In the production process of arsenic alloy, smelting ore, with added arsenic minerals, leads to a transition from arsenic alloy to tin. However, after transitioning from quartz or sulfide to more abundant ores, conditions were created in the furnace, which made it impossible to produce alloy metals. This phenomenon relies on socioeconomic processes, as it stimulates the growth of metal consumption and the demand for the use of other types of ores. When arsenic alloys were widely used, the social structure and trade methods may differ from the later period when tin was used. For example, using arsenic alloys for metal processing may rely more on local resources, as arsenic may have been considered a common and accessible element at the time. With the advancement of technology, people are starting to use tin, which may require more trade exchanges because tin may not be as easily available as arsenic.

Surprisingly, the metal statues are made of copper-based alloys and cast, using "lost wax casting", but the coal-based furnace design is too outdated and is also made of traditional clay. Coal processing and high smoke pose a threat to the artisans' health, which also indicates deficiencies in ancient metallurgy (Samanta, 2022, p. 395). Iron products have always attracted researchers due to their excellent corrosiveness, and the corrosion resistance of iron, produced by traditional metallurgical methods, is very high (Dwivedi, 2021, p. 1). The contribution and influence of ancient Chinese metallurgical culture on the development of ancient civilization, in China and the world, are significant, leaving tangible and intangible cultural heritage to people. Therefore, it is necessary to combine theory and practice to inherit and develop metallurgical culture (Sun, 2010, p. 1). Recently, the relationship between modern understanding of "metallurgical technology" and the "forgotten technological dimension" has attracted scholars' attention. In the constantly changing economic and political context, the research on metallurgical methods and their generation dimensions in ancient China are insufficient, which may provide an alternative method for the existence of technological generation and its ontological roots (Wu, 2023, p. 1). The ancient Chinese mining and smelting culture is an important component of Chinese culture and plays an important role in the history of world technological civilization. Inheriting and developing the ancient Chinese mining and smelting culture are of great significance to promoting the construction of material civilization and spiritual civilization in contemporary China.

1 Metallurgical technology culture at different levels

1.1 Metallurgical technology culture as a traditional social and cultural aspect

China's traditional social culture is a concept with a broad meaning, which is the main content and core of Chinese civilization, and also an important symbol of China's difference from other countries. As far as its content is concerned, it mainly includes folk culture,

clothing culture, food culture, language culture, religious culture, traditional technology or handicraft industry, etc. Metallurgical technology culture is a subculture of traditional Chinese culture, and it plays a role in the material basis of traditional Chinese society and culture. At the same time, the institutional and conceptual aspects of culture, related to metallurgical processes, have enriched the cultural connotations of traditional Chinese social culture to a certain extent, and have also greatly promoted it (Degli; Alexia, 2020, p. 179). Due to the invention, development and changes of any metallurgical technology, new cultural factors have been added to traditional Chinese social culture, thus enriching the original cultural system. At the same time, society itself would also strive to adapt to it, assimilate it, or adjust and transform the old cultural system with corresponding cultural forms, thereby promoting the evolution of culture.

Therefore, in this sense, metallurgical technology is the fundamental driving force behind the evolution of traditional Chinese culture. Of course, the impact of metallurgical technology on traditional Chinese social culture is mainly reflected in the emergence and dissemination of metallurgical technology culture. In other words, the invention of a metallurgical technology not only reflects the richness of traditional Chinese culture, but also infiltrates other cultural elements, or forms a new cultural element with other technological combinations. For example, bronze smelting technology has formed a unique and extremely brilliant bronze culture in ancient China, as the initial function of the Bronze Age was mainly as a sacrificial tool. Therefore, it has formed a unique bronze sacrificial culture. Whether it was the bronze vessels it used, the bronze motifs on the vessels with strong religious overtones, or its burial objects and the place and manner in which it was placed, all had a great influence on the traditional Chinese society's religious culture.

The progress of metallurgical technology has had a profound impact on trade patterns. With the development of metallurgy, people can manufacture more complex and durable metal items, which has expanded the scope and scale of trade. Remote trade has become possible, and the exchange of goods is not limited to neighboring regions, but it has expanded to even further afield. At the same time, the trade of metal products also promotes communication and interaction among different civilizations.

1.2 Metallurgical technology culture as a layer of objects

The development of metallurgical technology has played an important role in the society's progress and development. From the earliest Bronze Age to modern high-tech metallurgy, the progress of metallurgical technology has driven the human society's development, changing people's production methods, living conditions and living standards. The development of metallurgical technology has played a crucial role in economic prosperity and wealth accumulation. Metallurgical materials have become important ones

for manufacturing tools, building structures, transportation vehicles and weapons, and have had a profound impact on the society's economic development.

Human civilization begins with the production of tools, which are divided into the Stone Age, the Bronze Age, the Iron Age and Today's Steel Age. The long process of invention and development of human smelting technology began from the ancestors' recognition of the first type of copper ore (malachite) in nature, from simplicity to refinement, and from singularity to comprehensiveness (Dyakonov, 2019, p. 355). The bronze civilization of the Shang and Zhou dynasties was the most outstanding culture of the Bronze Age, the foundation of Chinese culture, and also the most outstanding culture of the Bronze Age. In the whole Bronze Age, in addition to a large number of bronze vessels, people also made a large number of agricultural production tools and other hand ones, weapons, etc., which greatly improved social productivity and promoted social development and civilization progress.

Nowadays, with the discovery of archaeology, batches of exquisite bronze ware have emerged in front of people. This is both an exquisite metallurgical technique and a rich bronze culture (Greenfield Haskel; Arkadiusz, 2021, p. 275). Through the sum of the material and spiritual production capabilities, obtained by these people in the practice of bronze smelting, as well as the material and spiritual wealth created, people can also see the cultural charm of this era. There are significant differences between ancient China's metallurgical practices and the ones of Western civilization. In the West, the focus of metallurgy is on manufacturing metals with specific physical properties, such as hardness, toughness and corrosion resistance. In China, the focus of metallurgy lies in exploring the inherent essence and changing laws of metals through philosophical practices, such as alchemy, in order to achieve the transformation and extraction of metals.

The ancient metallurgical culture has left behind rich material and intangible cultural heritage, which has had a profound impact on modern society. In terms of material cultural heritage, China's bronze ware can be taken as an example. Bronze ware is a representative product of ancient Chinese metallurgical practice, such as the Simu Wuda square cauldron. These exquisite bronze objects not only showcase the advanced level of ancient metallurgical technology, but also carry rich historical and cultural information. Nowadays, these bronze artifacts have become important collections in museums, showcasing the prosperity of ancient civilization to modern people.

China has entered the Iron Age from the end of the sixth century BC to the beginning of the fifth century BC. As early as the fifth century BC, China had already discovered and applied pig iron. With the popularization of iron, China's production efficiency had been greatly improved. Especially the smelting technology of pig iron has undergone significant development, such as decarbonization of iron, and firing and casting of iron, which have greatly promoted China's economic, political, cultural and military development. The use

of materials, such as copper, iron and steel, has also driven the development and progress of other industries in society (D'Amore, 2017, p. 58). As a result, under the joint action of these materials, a social force has emerged, which is the driving force for the ancient Chinese society's development. Moreover, ancient Chinese currency was also based on various natural products, such as seashells, or cast from metals, such as copper coins, iron coins, and even gold and silver coins. It is precisely because of the coins cast with this metal material that the circulation of goods can be promoted to a certain extent, promoting the development and prosperity of the social economy.

At the same time, metal currency itself and the cultural information it carries are also a part of traditional Chinese culture. Through these special currencies, they showcase the social characteristics and cultural atmosphere of different eras and regions, filled with rich elements of traditional Chinese culture. From this point, it can be seen that metallurgical technology is not only an external manifestation of traditional Chinese culture, but also an important component of cultural factors in the Chinese society's development process. The cultural nature of metallurgical technology is first reflected in materials, such as copper ore and (blue) copper ware, and iron ore and ironware. They are not naturally generated, but artificially manufactured. Therefore, if metallurgical technology is culture, then, from the perspective of artifacts, it means that metallurgical technology is consistent with the connotation and characteristics of culture, and it embodies the achievements of human material creation.

1.3 Metallurgical technology ideology and culture as a philosophical perspective

Exploring metallurgical technological ideas and culture, from a philosophical perspective, can expand the field of philosophical research. Attention can be shifted from traditional metaphysical and ethical issues to new fields, such as the relationship between technology and culture, and the social significance of technology, enriching the content and methods of philosophical research.

According to dialectical materialism, there is a universal connection between thinks in the material world, and every occurrence is directly or indirectly related to its environment (Chen, 2020, p. 12). There is a universal connection among various metal minerals in nature, which is actually the symbiosis of various metal minerals in nature. Ancient Chinese metallurgical craftsmen have long realized and deeply understood this, especially in the practice of "prospecting" by metallurgists. The *Guanzi* - Earth Numbers records the symbiotic relationship among seven metals, including iron, copper, lead, tin, gold, silver and mercury, all of which are valuable data in the history of ancient mineral development in China. In addition, some special metal elements have a special effect on the growth of plants, so

experienced blacksmiths would search for metal mines based on the growth status of plants. There are similar records in Volume 16 of *Youyang Miscellaneous Articles*, Duan Chengshi's previous collection, which belongs to the Tang Dynasty: : "There are onions on the mountain and silver underneath; there are scallions on the mountain and gold underneath; there is ginger on the mountain and copper and tin underneath" (Greenfield Haskel; Arkadiusz, 2021, p. 275). From this perspective, ancient Chinese metallurgical craftsmen not only had a profound understanding of the physical properties of various metals, but also had a profound understanding of their internal connections. This actually extends the mutual connection among homogeneous categories to the connection among no non-homogeneous categories, resulting in a simple and accurate dialectical idea of "[…] universal connection of things in the material world" (He, 2022, p. 101).

The heaven, earth and human beings' "Three Talents" ideology is an important philosophical system in the history of ancient Chinese philosophy (Zhang; Liu; Wang, 2023, p. 114). It regards heaven, earth and human beings as the three basic elements that make up the world, and emphasizes the important significance of the coordination and unity of the three. The "Three Talents" ideology is not only a cosmic concept, but also a methodology, so in ancient China, it was often used to explain some related phenomena and problems. It can be said that ancient Chinese people applied the concept of heaven, earth and human beings' "Three Talents" to various technological practices. Every scientific and technological department in ancient China had its own unique scientific and technological concepts in the specific application of the "Three Talents" theory. Taking the practice of agricultural technology in ancient China, as an example, its "Three Talents" concept is "24 solar terms", "constantly new soil conditions", "fine cultivation", and so on.

Similarly, ancient Chinese craftsmen were deeply influenced by this concept in the practice of metallurgical technology. For example, in the book *Kaogongji*, it is said: "The year has seasons; the ground has spirit; materials are esthetical; techniques are skillful. Combining these four factors can then be considered good" (Greenfield Haskel; Arkadiusz, 2021, p. 275). Among them, "the year has seasons", "the ground has spirit" and "techniques are skillful" are specific details of the "Three Talents" thought. Ancient China's metallurgical technology and culture not only enriched Chinese social culture, but also had its own unique cultural characteristics, which can be said to be one of the essence of Chinese social culture (Wang; Zang, 2022, p. 95).

1.4 Metallurgical technology culture as an institutional layer

As a culture of metallurgical technology at the institutional level, it includes planning, rules, management, organization, distribution system, reward and punishment system, etc., in the practical process of metallurgical technology (Giumlia-Mair, 2018,

p. 643). The metallurgical industry is a highly comprehensive production department, consisting of a series of processes, such as prospecting, mining, beneficiation, crushing, transportation, furnace casting, fuel preparation, smelting, molding, ingot casting, forging and processing. Such complex processes inevitably involve planning, management, rewards, punishments and other systems. As for its organization and management, there is a detailed record in the *Zhouli* - Di Guan: "The people in charge of the land of gold, jade, tin, and stone were strictly prohibited to guard it. If it was taken at the time, it would be given based on its map, and it would be prohibited to patrol it" (Giumlia-Mair, 2018, p. 643). It is also said that "[...] the people in charge were two sergeants, four corporal, two people from the government, two officials, four petty officials, and forty disciples" (Giumlia-Mair, 2018, p. 643). From this perspective, the mining industry of this era not only had a profession, but also its responsibilities (referring to metal mines, jade mines, tin mines and stone mines) and clear division of labor, as well as its personnel composition: sergeant, corporal, government, officials, petty officials and disciples.

In the Han Dynasty, in order to control the country's iron smelting industry, Emperor Wu of Han implemented a policy of salt and iron official management, and established iron officials in the country's main iron smelting areas, as well as small iron officials in areas where iron was not produced, to "sell old tools and cast new ones". By the Song Dynasty, the mineral industry was unified and managed by the central authorities, consisting of three ministries, including the Ministry of Salt and Iron, the Ministry of Revenue and the Ministry of Household, which were responsible for various economic aspects, such as finance, trade and household accounts. Among them, the Ministry of Salt and Iron is in charge of the goods of the mountains and lakes in the world, as well as the affairs of customs, rivers and canals, and military weapons, for the use of the capital state. Because there are many things to deal with, so the Ministry of Salt and Iron is divided into seven cases. Ironclad case is a specialized organization under the Three Departments, responsible for various mining affairs. Each mining area has its own production department, which includes supervision, smelting, workshops, mines, and so on. This not only strengthened the country's control over the mining and metallurgical industry, but also further developed the ancient Chinese business culture.

In summary, metallurgical technology culture is a subsystem of technological culture. In terms of its connotation, metallurgical technology culture is the sum of material and spiritual assets generated by ancient metallurgists in the long-term technological practice of understanding, utilizing and transforming metals. It includes values, moral norms and codes of conduct, which are commonly followed and believed in by certain groups in society (including people at all levels of metallurgical technology development, and metallurgical technology utilization and learning). With the continuous and rapid development of metallurgical technology socialization, the existence domain of metallurgical culture is

also constantly expanding and ultimately becoming an important organic component of social culture. Therefore, people often say that metallurgical technology culture is a rapidly developing subculture. It not only contains the basic characteristics of some subjective culture (such as science and culture), but also has its unique elements, combination and movement mode, which conforms to its operation rules.

The types and characteristics of metallurgical technologies are shown in Table 1. For example, bronze smelting is a smelting technology that uses copper and tin as the main materials, which are melted and cast into shape.

Table 1 – Types and characteristics of metallurgical technologies

Serial number	Technology type	Characteristic
1	Bronze smelting	Smelting technology using copper and tin as the main materials, melted and cast into shape
2	Iron furnace smelting	Smelting technology for producing iron by melting iron ore using carbon as a reducing agent
3	Steel furnace smelting	Smelting technology for producing high-quality steel through the joint smelting and refining of carbon and wrought iron
4	Hydraulic smelting	Technology for smelting and making handicrafts using hydraulic transmission of grinding stones and other instruments
5	Blast furnace smelting	Smelting technology that utilizes wind power to increase furnace temperature, accelerate material reaction and melting
6	Shot blasting smelting	Smelting technology that utilizes wind power to impact materials, causing them to generate frictional heat and melt
7	Sintered iron smelting	Powder metallurgy technology, smelting technology obtained by high-temperature sintering of molten zinc ore and sintered iron
8	Carbonized wood smelting	The core technology of carbonization using wood under air isolation conditions

Source: Gluzman (2017, p. 21)

2 Philosophical thought in metallurgical technology culture

2.1 Thought of "harmony" in philosophical thought

The idea of "harmony" is an important philosophical thought in the ancient Chinese philosophical system. The essence of this philosophical thought is "harmony but difference" and "harmony with reality" (Cai, 2018, p. 108). The term "harmony" here, if viewed from

modern philosophical thought, refers to the formation and balance of different things, and the emergence of new things through it, which is a qualitative change. "Same" refers to the repetition or simple addition of the same thing, so that it still retains the characteristics of the original thing, so it is impossible to produce new things. It is a quantitative change of inaction, and this simple superposition of inaction would only suffocate the vitality of things. Therefore, the so-called "harmonious entity" refers to the combination of many things with different functional attributes in a certain structural order, resulting in a new substance (whole).

Applying the philosophical idea of "harmony" to various practical technical fields, in ancient times, has formed the technological concept of "harmony". In ancient China, metallurgy was a technical department with the basic starting point and ability of making utensils, production tools, living utensils, weapons, ritual vessels, etc., which was deeply influenced by the philosophy of "harmony" or the concept of technology. In ancient China, eight metals have been identified for smelting and application, namely copper, gold, lead, tin, iron, silver, mercury and zinc, with copper and iron being the main ones. From the Xia Dynasty to the Qing Dynasty, for about 4000 years, the application of metals experienced two main development periods. In the first period, bronze dominated the previous stage for nearly 2000 years, and various metallurgical technologies were developed with bronze as the main body, forming the brilliant bronze culture of the Yin and Shang period (O'G Ochilov, 2021, p. 42). Over the next two thousand years, the world was dominated by cast iron and steel, and a unique steel culture developed on the basis of pig iron smelting. Whether in the Bronze Age or the Steel Age, their practices were filled with the philosophical thought of "harmony".

In ancient Chinese metallurgical technology, there existed a unique path of liquid metallurgy, which led Chinese blacksmiths to create pig iron casting technology over two thousand years ago, making pig iron casting technology unique in the world for over 2000 years (Vicas, 2020, p. 149). In ancient China, blacksmiths created pig iron casting technology with complete blast furnace facilities (shaft furnaces), powerful blast furnace equipment (furnaces), sufficient fuel (charcoal) and related technical experience (mainly bronze casting technology). This greatly improves the efficiency of cast iron usage and brings convenience to casting. It has promoted the popularization of ironware and played a huge role in promoting the progress of social productivity. From ancient China's philosophical perspective, the invention of this craft was the result of "harmony" because, on the basis of perfect shaft furnace facilities, advanced blast technology and equipment, and other related technological controls, harmony and difference led to a new technological invention : pig iron smelting and casting technology.

2.2 Philosophical thought of "harmony" in ironmaking (steelmaking) technology

To invent a new smelting technology, there must be two basic conditions: one is to have sufficient casting capacity, and the other is to have sufficient high-temperature smelting technology, which happened to be possessed by ancient Chinese metallurgical technology (Liu; Zhang, 2023, p. 1). Firstly, there has been a history of casting bronze since the Yin and Shang dynasties. For example, the famous "Shanghoumuwu Cauldron" is a typical example of this process. To achieve success in this process, it is necessary to have good smelting equipment (such as a shaft furnace) and advanced casting technology (such as "internal heating"). Secondly, the blast technology is constantly improving, which is also the key to pig iron smelting and casting. During the Yin and Shang dynasties, people had already adopted the method of skin blowing to heat the furnace temperature, in order to achieve a melting point of about 1000℃.

Later, as time passed, the blacksmiths continuously improved their ventilation devices and eventually discovered a larger ventilation device called "Ligularia", which could raise the temperature of the furnace and make the molten iron hotter. Therefore, ancient Chinese blacksmiths created pig iron casting technology with complete ironmaking facilities (shaft furnaces), powerful ventilation devices (Ligularia), sufficient fuel (charcoal blocks) and corresponding process experience. The emergence of molten iron greatly improved the efficiency of cast iron use. From ancient China's philosophical perspective, the invention of this technology was a concept of "harmony".

The emergence of pouring steel was a significant technological creation in the development history of ancient Chinese steel technology. Pouring steel is also known as cluster steel. Its basic principle is to mix pig iron and wrought iron in a certain proportion for smelting, which is called miscellaneous smelting. Since the properties of pig iron and wrought iron are completely different, their physical and chemical properties are also different. According to the theory of metallurgy, pig iron and wrought iron are distinguished according to the carbon content. Pig iron is a fragile metal that contains a large amount of carbon and impurities. Therefore, it cannot withstand plastic deformation. Mature iron is soft, with good plasticity and toughness, high magnetism and a very narrow application range. However, if these two materials can be "combined" together, they form a new material (steel). Its use and scope have expanded, which is a huge progress. This indicates that, under the guidance of the concept of "harmony", ancient Chinese blacksmiths connected and fused pig iron and wrought iron to create steel materials that are still significant for human modernization today (Frey; Volker; Christian, 2018, p. 1384).

Contemporary philosophy emphasizes that reason is not the highest, but it is necessary to transcend the epistemology of modern philosophy on the basis of ontology. This

philosophical perspective has enlightening significance for the development of metallurgical processes, as it emphasizes both production efficiency and people's sustainable development and of the environment. For example, in metallurgical production, it is necessary to ensure the yield and purity of products, while also considering energy consumption, damage of pollutants to the environment, and the impact of workers' health and safety. Secondly, it emphasizes the need to achieve a state of "harmony" between humans and nature. This provides us with an inspiration that, in design and execution, excessive exploitation of natural resources and damage to the ecological environment should be minimized as much as possible. For example, by improving processes, technologies, improving resource utilization efficiency, reducing waste emissions and adopting circular economy, we can achieve harmonious coexistence between humans and nature.

From the history of world metallurgical technology development, natural copper is the first metal used by humans (Zhou, 2019, p. 14). So far, the earliest natural copper artifacts, discovered by archaeology, were unearthed in West Asia. However, artificial copper, extracted from copper mines, is much later. According to archaeological excavations, copper smelting technology only emerged in China in the late Neolithic period, which is 4000 to 5000 years ago. This indicates that, although ancient Chinese smelting technology was not the earliest to appear, it was advanced, with tin bronze alloy technology being the most prominent. This is also why ancient China had such a brilliant bronze culture.

The development of tin bronze alloy technology is due to the philosophical thought of "harmony", in ancient China, and its influence on metallurgical technology. The philosophical thought of "harmony", in ancient China, deeply influenced the smelting process, and based on this, the smelting process was explored. This concept emphasizes balance and coordination, specifically in metallurgical processes, manifested as selecting materials, grasping the process, and pursuing the quality and performance of the finished product. This philosophy prompted ancient metallurgists to reach a new height in their requirements for details and craftsmanship (Fielitz, 2013, p. 72). However, the philosophy of "harmony" is not limited to ancient smelting techniques. This method is still widely used in contemporary metal cutting. For example, high efficiency, high quality, high consistency and high reliability are the development trends of modern metal manufacturing technology. This is consistent with the philosophical concept of "harmony" in ancient China, which emphasizes balance and harmony.

2.3 Philosophical thought of "harmony" in ancient Chinese bronze smelting and casting technology

Copper is one of the earliest metals discovered and used by people, but due to its soft nature, the tools made from it cannot fully meet people's production and daily

needs (Liu, 2020, p. 594). Therefore, in specific metallurgical practices, the first people, through their knowledge of other metals, such as lead, zinc and tin, consciously smelted ores containing these metals together with copper-bearing ores, thus smelting copper alloy materials containing copper, zinc, or tin or lead: bronze (Chen, 2021, p. 185). The ultimate development was to first smelt copper, tin, lead, or lead-tin alloys separately and, then, mix and melt them according to a certain proportion. This resulted in a relatively stable composition of the bronze, and the composition ratio could be changed according to the requirements of different artifacts. This is the development of ancient Chinese copper materials, which included the concept of "harmony". As it is well known, copper is soft, and tin is also soft, but when these two soft materials "blend" together, they form a new, better and harder material that can be used for forging. According to *Lv's Spring and Autumn* - Other Categories, "Gold (i.e. copper) is soft and tin is soft, and when combined with two soft pieces, it becomes hard" (Chen, 2021, p. 197). This is an earlier account of alloy strengthening in the world.

The philosophy of "harmony" in China emphasizes the reconciliation, unity and balance of differences; in metallurgy, this concept is mainly manifested by mixing different metal components and minerals to form alloys with special properties. Its core is to seek and leverage the complementary roles among various elements to achieve a balanced and harmonious state. On the contrary, ancient Greek philosophy placed greater emphasis on rational and logical thinking. This philosophy is also reflected in ancient Greece'ssmelting activities. For example, when the Greeks made alloys, they always went through experiments and calculations to find the best ratio and mixing method. The philosophical concepts, in the Middle East, are more focused on mysticism and natural laws. In the process of smelting, this philosophical viewpoint is reflected in believing in witchcraft and supernatural powers, and exploring natural laws.

In the process of smelting tin bronze, the philosophical idea of "harmony" has been best interpreted. Two different textures of copper and tin undergo a strong chemical reaction. "Harmony" results in a new and rigid material: tin bronze. This material is the main part of the hierarchy of artifacts in ancient Chinese bronze culture (Yan, 2021, p. 1). Here, the "harmony" and the "rule" are connected, so that the change from "soft" to "rigid" becomes more graphic. In the history of metallurgical technology, the development, from a single material to a composite material, is a huge leap in the development of metallurgical technology. Especially in the field of metallurgical processes, its application has developed from a single metal to an alloy. This alloying is not just a simple superposition of metals, but rather a creation of a new substance.

This conscious leap is the imprint of the philosophical thought of "harmony". In the "Kaogongji", it is recorded that

> [...] there are six levels of gold, with six levels of gold and tin ranking first, which is called the level of Zhong Ding; five parts of its gold and tin in one is called the axe catty of Qi; four points of its gold and tin in one is called the halberd of Qi; three points of its gold and tin in one is called the big blade of Qi; five points of its gold and tin in two is called the chipping, killing vector of Qi; half gold and half tin are called the Qi of Jiansui (Yan, 2021, p. 1).

This is a metal theory of the "Six Qi" method in ancient China, namely the bronze smelting and casting method, which is representative. Here, although he did not use the word "harmony", it was full of the philosophical concept of "harmony". The "Six Qi" is composed of two different elements. One is made of gold (i.e. copper) and the other is made of tin (i.e. harmony). In addition to the real world, ancient Chinese metallurgical technology has also left a deep imprint in the virtual world. Many electronic games, such as *The Legend of the Ancient Sword* and *The Legend of the Immortal Sword*, use ancient Chinese metal products as weapons and equipment. These games are not only very popular among Chinese players, but they are also very popular worldwide. Through these games, the younger generation can learn about the rich history and cultural connotations of Chinese metal products.

Due to the different contents of copper and tin, as well as the different proportions of copper and tin in metals, they are used to make bell and tripods, axe and jin, spear and halberd, large blades, cutting, killing arrows, Jian Sui, etc. (Zhang, 2022, p. 31). The techniques and principles in metallurgical practice can be effectively applied in high-temperature treatment of materials and various metal element compounds, which provides a foundation for the glaze formula and sintering process in the ceramic firing process. The manufacturing methods of ceramics, such as mud refining, mold making and temperature control, during the firing process, are also deeply influenced by metallurgical technology.

Here, "harmony" refers to a state in which different elements or forces can coordinate and supplement each other, forming an organic whole. The overall structure and function of this system are superior to the sum of its individual components. In other words, harmony means overall coordination and balance, which is not necessarily static, but dynamic and can self adjust and adapt in changing environments. For example, in society, culture and philosophy, the philosophical idea of "harmony" has various forms of expression. For example, in traditional Chinese culture, "harmony" is considered an ideal social state. The Five Elements Theory is a typical way of expressing this harmonious thought. The five elements (wood, fire, earth, gold and water) represent the five elements or forces that maintain a dynamic balance through continuous interaction and transformation.

3 Reflection and discussion on society, culture and philosophical metallurgical technology

In order to better understand the current situation in China and the international situation, this article will provide a general discussion on the reflection of metallurgical technology in society, culture and philosophy. This course will also explore the impact of technology on the way we live, work, communicate and understand the world, explore how technology shapes our social, cultural and philosophical concepts, and explore how they affect the development of technology.

Analysis of China's current situation: China is a country with a long history and splendid culture, and its social, cultural and philosophical ideas have had a profound impact on the development of its smelting technology. Among them, the Chinese Five Elements Theory has had a profound impact on the development of smelting technology, and smelting technology plays an important role in the emergence and development of the Five Elements Theory. In addition, the Chinese people's values about nature and collectivity have had a certain impact on the development of metallurgical processes.

Then, global situation: under the current trend of global economic integration, smelting technology has crossed national borders and gone global. On a global scale, different cultures, societies, philosophies, etc. have had a profound impact on the development of metallurgical technology. For example, Western individualism and the pursuit of efficiency have had a certain impact on the development of smelting technology;

Finally, on this basis, this article will provide a review of the above two aspects of exploration, and also provide new ideas for the next step of research. For example, in the process of technological development, there will be more interdisciplinary collaboration and innovation; with the changes in society, culture and philosophical thinking, people will see more personal technology and environmental awareness.

Conclusions

Liquid metallurgy is a technology that extracts and refines metals by controlling chemical reactions and physical processes. Compared to traditional solid-state metallurgical methods, liquid metallurgy has higher production efficiency and less environmental pollution. By using more advanced equipment and materials, liquid metallurgy can achieve efficient metal extraction and refining, while reducing energy consumption and waste emissions. This philosophy also encourages people to continuously explore new production methods and processes. For example, by studying the characteristics and behavior of liquid metals, people have invented various metallurgical processes, such as casting, forging, rolling, etc. These

processes were widely applied in the later industrial revolution, promoting the development of industrialization.

Metallurgical practice has a profound historical and cultural background in Chinese civilization. The ancient metallurgical technology, such as copper and iron smelting, provided an important driving force for the development of Chinese civilization. These technologies have not only changed people's lifestyles, but also influenced social forms and cultural evolution. At the same time, Chinese civilization has also nurtured rich philosophical ideas, such as Confucianism, Taoism, Mohism and other schools of thought, which provide people with the life's principles and values. These philosophical ideals have also, to some extent, influenced metallurgical practice, such as the development and utilization of resources, technological innovation and development, all reflecting the influence of philosophical ideas.

The concept of "harmony" can also promote continuous innovation and progress in metallurgical technology. For example, in the smelting process, metal materials, with different structures and properties, can be obtained by controlling parameters, such as temperature, time and atmosphere. These new metal materials can have better mechanical properties, chemical stability and physical properties, thus being widely used in various fields. With the time's passage, China's metallurgical technology has gone through several important eras, from the Bronze Age to the Iron Age. This transformation is not only a change in materials, but also a manifestation of human civilization progress. In these changes, the philosophical concept of "harmony" has always permeated it, adding profound cultural connotations to the development of Chinese craftsmanship.

The long history of ancient Chinese metallurgical technology has formed China's unique metallurgical technology culture, which is the main component and core of traditional Chinese culture and the main driving force for promoting the development of Chinese civilization. There are many philosophical ideas in ancient metallurgical technology. In order to better apply philosophical ideas to metallurgical technology and promote its development, this article first analyzed the metallurgical technology culture, at different levels, and concluded that metallurgical technology culture includes the idea of "harmony". Only by integrating the "harmony" ideology into the culture of metallurgical technology, traditional metallurgical technology can be consistently reconciled, but differentiated. The "harmony" ideology has brought enormous significance to metallurgical technology. Exploring metallurgical technology ideas and culture, from a philosophical perspective, is of great significance. It can enrich the field of philosophical research, deepen the understanding of the relationship between technology and culture, and promote sustainable social development and humanistic care. Although the progress of metallurgical technology has provided abundant metal resources, such as copper, iron, tin, etc., the limited availability of these resources also restricts the development of metallurgical technology. In future work, the

role of more philosophical ideas, in metallurgical technology culture, should be studied to promote China's metallurgical technology.

The issues that need to be addressed in the future include, but are not limited to:

Sustainable development: with the increasing depletion of resources and environmental pollution, metallurgical technology needs to develop in a more sustainable direction, including challenges, such as reducing energy consumption, reducing waste emissions and improving resource utilization.

Technological innovation: with the continuous progress of technology, metallurgical technology also needs to be constantly innovated to improve the efficiency of metal extraction and processing, develop new materials and apply advanced processing techniques.

Social impact: the development of metallurgical technology also needs to consider its impact on society, including employment, local communities and the protection of cultural heritage.

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