Scholar Publishing Group
International Journal of Engineering Technology and Construction
https://doi.org/10.38007/IJETC.2020.010106
ISSN 2789-7176 Vol. 1, Issue 1: 72-85

Metal Matrix Composite Material Based on Wear Resistance in Sandstone Relief Fresco Exterior Wall Construction

Ankite Singha*

Jawaharlal Nehru University, India

**corresponding author*

Keywords: Metal Matrix Composites, Wear Resistance of Composites, Sandstone Relief Murals, Mural Exterior Wall Construction

Abstract: With the rapid development of social economy, the types of stone curtain walls have also been increased in the exterior decoration of buildings. Sandstone is a natural stone with strong abrasion resistance and a green decorative material with innovative and modern artistic characteristics. The plasticity and expressiveness of indoor and outdoor are very strong, and the artistic style is very special. This article proposes how to use the wear resistance of metal matrix composites on the basis of relevant theoretical knowledge to play the greatest role in the construction of sandstone relief murals. Experiments in this article show that the trend of using metal matrix composites has been rising by as much as 70% from 2016 to 2019, while the trend of using metal materials has been declining, as low as 13%. It can be seen that metal matrix composite materials are what the public needs. Metal matrix composites have an extremely important position in traditional wear-resistant materials and are widely used. The main reason is that the metal matrix composite material has the characteristics of low production cost, excellent toughness and good deformation hardening ability.

1. Introduction

With the development of the times, artistic expressions have become very rich, and people's aesthetic needs and choices have become more diverse. The form of modern art is constantly changing, and the performance of works only uses specific pure artistic language, which will inevitably appear monotonous. Relief murals have become an indispensable part of contemporary architectural design. And how to play the biggest role in the construction of sandstone relief murals based on the wear resistance of metal matrix composites has become a focus of attention. In recent years, in the construction machinery manufacturing industry, although the performance of

mechanical parts and mechanical operating systems has improved, there are still many weak links.

Traditional steel is mainly used for a variety of mechanical parts, and its shortcomings have also been clarified in the process of use, but in recent years, metal composite materials have become popular. Compared with traditional materials, metal composite materials have obvious advantages. Metal composite materials are lighter than previous steels. Moreover, the characteristics of metal composite materials are also suitable for mechanical manufacturing. At this stage, the performance of metal composites is relatively high.

With the development of society, researchers are paying more and more attention to murals. Researcher Coutinho M L proposed that the glaze and in-glaze pigments of the 19th century historical glazed tiles from Pena Palace (Sintra, Portugal) were characterized using multiple analysis methods. The chemical composition and microstructure characteristics are determined by μ-PIXE, μ-Raman, optical microscope and VP-SEM-EDS. It was found that the manufacturing technology and color palette of these tiles were similar to the ceramic pigments used in traditional enamels. Blue and purple are from cobalt oxide and manganese oxide, green and dark yellow use a mixture of Pb-Sn-Sb yellow, cobalt oxide and iron oxide, and the gray tone is composed of different proportions of cobalt oxide, manganese oxide and Pb-Sn- Sb yellow complex composition. The results obtained confirm the use of oxides and elements in the pigments and production techniques, using traditional enamel manufacturing, even though the tiles were produced at the end of the 19th century [1]. Jancewicz K proposed that the identification of structural connectivity is particularly challenging in terrain lacking a layered river system, but its typical characteristics are strong bedrock control, extremely rugged terrain, the presence of sinks (closed depressions) like karsts, or significant changes due to human intervention. In this article, to solve the problem of connectivity mapping in the sedimentary platform under such a very rugged terrain-sandstone, mudstone and marl. Three specific geomorphological backgrounds were selected for detailed research. These are the steep cliffs, the back slopes of the Kusta gorge and the remaining slab hills (platforms), with a relative terrain of 100-300 m. This work is mainly based on topography measurement methods, using topographic moisture index as a tool to identify water and possible sediment transfer paths through sandstone platforms. In addition, a distribution map of closed depressions was also generated. The high-resolution (1 m) digital terrain model provides input terrain data [2]. Zabolotnov AS discovered the tribological properties of ultra-high molecular weight polyethylene (UHMWPE) composite materials and organically modified montmorillonite (MMT), nano graphite flakes (GNP), molybdenum disulfide, magnesia and other fillers under different actions And abrasion resistance. According to the results obtained, these fillers are introduced into UHMWPE in an amount of 0.4-7 wt%, and there is almost no effect on the sliding friction coefficient of steel in the dry friction mode. In the case of sliding friction on steel, the composite material with GNP, MoS 2 and zinc blende is characterized by significantly improved wear resistance (two to three times). In the case of friction on sandpaper, the wear of composite materials is greatly affected by the type of filler, and the use of MMT is the most effective way to improve the wear resistance of composite materials [3]. Inl A studied the electro-corrosion and wear resistance of silver-based composites (CM) reinforced with superelastic hard carbon particles obtained by fullerene under pressure. As the carbon phase content increases to 30 wt%, the wear resistance of CM increases by two orders of magnitude, and the friction coefficient decreases from 1.12 to 0.21. However, the resistivity of CM increases as the carbon content increases above 10%. Compared with silver, CM with 10% reinforcing phase has similar resistivity, lower friction coefficient, and significantly higher wear resistance and electrical corrosion wear resistance [4]. Chen PH researched that the wear resistance of iron (Fe)-based materials can be improved by in-situ formation of high-hardness vanadium

carbide particles (VCp). However, due to the added high carbon content, brittleness and low impact toughness limit their application in many industries. Carbon distribution treatment plays an important role in adjusting the in-situ VCp to enhance the microstructure and mechanical properties of Fe-based composites. In this study, the effects of carbon distribution temperature and time on the microstructure, mechanical properties and wear resistance of in-situ VCp reinforced iron-based composites were studied. Experimental results show that a certain amount of retained austenite can be stabilized at room temperature through carbon partitioning treatment. After carbon distribution treatment, the microhardness of the in-situ VCp reinforced Fematrix composite material will decrease, but with the improvement of wear resistance, the impact toughness will increase correspondingly [5]. Karimbayev T D found that polymer composites (PCM) are increasingly used in the aircraft engine industry. The development of PCM fan blade manufacturing technology that meets all necessary strength requirements is an important task in the manufacture of the latest generation of engines made in Russia. One of the problems that needs to be faced is blade root wear caused by periodic micro-displacement in the interlock under the action of external force. There are several engineering solutions to control the wear on the root surface of blades made of PCM, and they can basically be divided into three categories: the manufacture of metal roots and the use of known metal fretting prevention methods, the use of special replaceable inserts placed between the contact surfaces of the blades, and the application of roots and disk grooves, elastic and damping elements.In this article, we consider another method to control wear, the main feature of which is to stitch blade preforms with aramid threads to form a layer with higher wear resistance on the root surface [6]. Tian S X observes the three-body high-stress abrasive wear test and SEM wear surface micro-morphology observation, and compare high manganese steel and Al2O3 ceramics to enhance the wear resistance of high manganese steel. By testing the surface microhardness, the wear and hardening of the two materials are studied. The results show that there is no metallurgical bonding, and the mechanical joints are tight [7]. AS Y studied the effect of nanoparticle orientation on the wear resistance of transparent composite coatings. Using the nozzle spraying method, halloysite nanotubes (HNT) are arranged in in-plane and out-of-plane directions and in various random orientations. Nano scratch, falling sand and Taber wear tests are used to characterize wear resistance at different length scales, and composite materials always show better wear resistance than pure epoxy resin. The samples with out-of-plane particle orientation showed better wear resistance than those with in-plane particle distribution. In the nano scratch test, the out-of-plane orientation reduces the normalized scratch volume by 60% compared to pure epoxy. In the falling sand and Taber wear tests, based on the stylus profile measurement method and SEM observation, the halloysite particles arranged out-of-plane resulted in a smaller surface roughness [8]. Through the research and analysis of scholars, it can be known that due to the relatively strong wear resistance of the metal matrix composite material, the composite material plays a great role in the construction of sandstone relief murals, and how to apply the good wear resistance of composite materials to the construction of sandstone relief murals is the biggest problem.

The innovations of this article are: (1) After explaining the relevant theories, the principal component analysis method is selected to analyze the use of metal matrix composites in the relief murals. (2) Through the experimental analysis of the wear resistance of pure metals and metal matrix composites, and the questionnaire analysis of the materials used in the murals on the market, we know that metal matrix composites are the general trend.

2. Principal component analysis method

2.1. Metal Matrix Composites

The reinforcing materials of metal matrix composites are mostly inorganic non-metals, such as ceramics, carbon, graphite and boron, etc., and metal wires can also be used [9]. It forms modern composite materials together with polymer matrix composite materials, ceramic matrix composite materials and carbon/carbon composite materials. As shown in Figure 1:

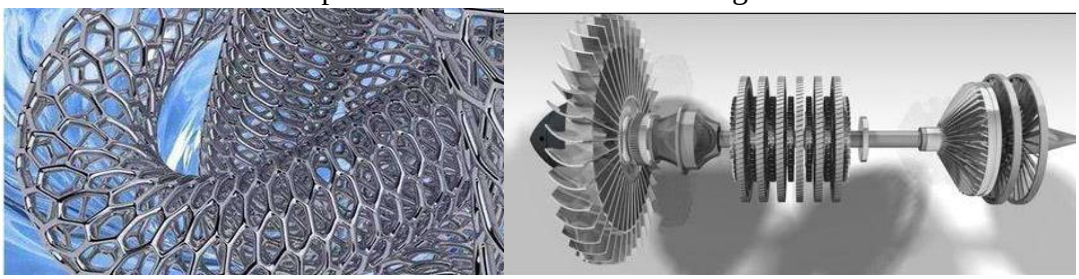

Figure 1. Application diagram of modern composite materials in daily life

As shown in Figure 1, using scanning electron microscope observation, X-ray microanalysis, microhardness testing and other high-tech methods to analyze the interface structure of the metal matrix composite material, and use a roller wear tester to measure the high temperature wear resistance of the metal matrix composite material. And compare its wear resistance test results with the base material[10-11]. The wear resistance of composite materials is better than that of matrix materials, and the advantages of composite materials are the most obvious. This article takes the construction technology of the outer wall sandstone relief mural as the starting point, and analyzes the manufacturing, installation characteristics, principle, technical process and application points of the outer wall sandstone relief mural so as to make recommendations on quality and safety. As shown in Figure 2:

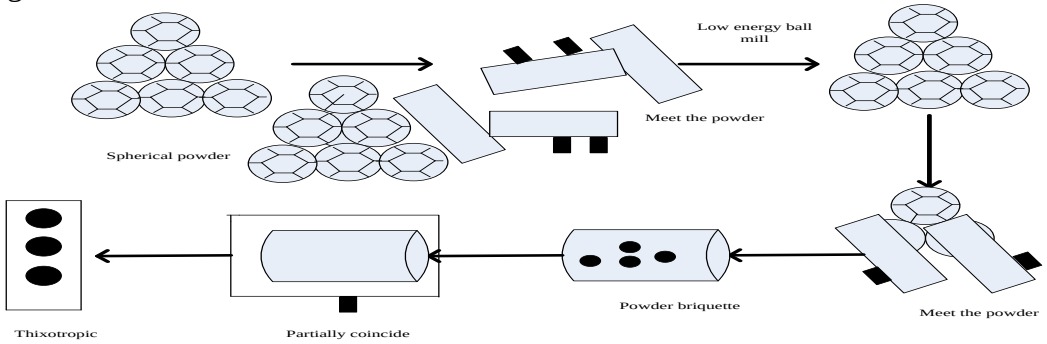

Figure 2. Schematic diagram of composite materials

As shown in Figure 2, nowadays, with the continuous development of society, the appearance of buildings is very different from before. It is believed that many people are still relatively new to sandstone reliefs. Sandstone is a kind of sedimentary rock, which is the stone formed by the erosion and precipitation of water, the accumulation of thousands of years of orogenic movement [12]. Here I take you to understand the use of sandstone reliefs in modern architecture as shown in Figure 3:

Figure 3. Relief process diagram in modern architecture

As shown in Figure 3, classical culture is becoming more and more popular in modern architecture, and the combination of architecture and relief techniques can better reflect the characteristics of architecture and regional culture. In particular, the application of sandstone relief is slowly increasing. Because of the large-scale sandstone, in cultural places, parks and other places, it can be seen that reliefs and buildings are combined to form a single structure, and the buildings are processed [13].

2.2. Principal Component Analysis Method Calculation

In actual problems, in order to analyze the problem comprehensively, many influencing factors need to be considered, namely indicators, also known as variables. In most cases, there is a certain correlation between variables [14]. Therefore, if the number of variables is large, the complexity of the problem and the amount of calculation for data processing and analysis will be greatly increased. As a result, some data dimensionality reduction techniques have been produced, and principal component analysis is one of them.

When selecting the first new variable Q_1, it should express as much information as possible, that is, the larger the variance of this new variable, the better. If Q_1 is not enough to express the original information, continue to select the next new variable Q_2. In order to effectively reflect the original information, the information in Q_1 no longer appears in Q_2. In this way, continue to select new variables until the amount of information expressed meets the user's requirements [15]. These new variables are called the first principal component in turn, and the second principal component is as formula 1:

$$Q_1 = a_{11}Y_1 + a_{12}Y_2 + ... + a_{1P}Y_P \quad (1)$$

Obviously, these principal components are not only linearly independent, but the variance is also decreasing. Each principal component is as formula 2:

$$Q_2 = a_{21}Y_1 + a_{22}Y_2 + ... + a_{2P}Y_P \quad (2)$$

Therefore, the calculation requirements of the principal component analysis method are as formula 3:

$$Q_M = a_{M1}Y_1 + a_{M2}Y_2 + ... + a_{MP}Y_P \quad (3)$$

Determine each principal component Q_i, $i=1,2,...m$ about the original variable X_J, The expression of $J=1,2,...,P$, which is the coefficient $i=1,2,...m$, $J=1,2,...,P$. It is known from mathematics that the variance of the principal component is actually the eigenvalue of the original variable covariance matrix. The principal component load is calculated, and the principal component load is calculated. Q_i reflects the correlation between the principal component and the original variable as formula 4:

$$P(Z_k x_i)=\sqrt{\lambda_k a_{ki}}(i=1,2,...,p,k=1,2,...m) \quad (4)$$

The covariance matrix of the original data is calculated by formula $\sum(A_{ij})p^{'}p$, where formula 5:

$$A_{ij}=\frac{1}{n-1}\sum_{k=1}^{n}(x_{ki}-x_i)(x_{kj}-x_j) \quad (5)$$

Find the eigenvalue $\sum$ of λ_I and the corresponding orthogonalized unit eigenvector a_i

The first m larger eigenvalues $\sum$ of $\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_M \geq 0$ are the variances corresponding to the first m principal components, and the unit feature vector λ_2 corresponding to a_i is the coefficient of the original variable of the principal component Q_i, then the i-th principal component Q_i of the original variable is formula 6:

$$Q_i=a_i^{'}X \quad (6)$$

The variance (information) contribution rate of the principal component is used to reflect the amount of information, and a_i is Formula 7:

$$\alpha_i=\lambda_i/\sum_{i=1}^{m}\lambda_i \quad (7)$$

Choose the principal components ultimately requires selecting several principal components, namely Q_i, and the determination of m in $i=1,2,...,m$ is determined by the cumulative contribution rate $G(m)$ of variance (information), which is formula 8:

$$W(m)=\sum_{i=1}^{m}\lambda_i/\sum_{k=1}^{p}\lambda_k \quad (8)$$

Then you can take the first m principal components. According to the mathematical formula, we can know that the covariance obtained after using standardization to modify the calculation and processing variables is the same as the correlation coefficient of the variables. In other words, the covariance of the variable obtained after standardization is the original correlation coefficient of the variable. In addition, it can be inferred from the covariance formula that the standardized covariance is the correlation coefficient matrix of the original variable. Therefore, the correlation coefficients of the original variables before and after standardization are the same.

2.3. Methods to Integrate into Regional Cultural Feelings

A good relief mural design can improve the urban environment and artistic aesthetics in terms of function, structure, technology, and craftsmanship, which makes the surrounding related architectural environment have a strong cultural connotation and artistic atmosphere [16]. Therefore, it is necessary to consider the construction of relief murals in the general environment, and consider its advantages in combination with the environment. Of course, if you want to build a commemorative relief to show the hope of the people, it is also very important in site selection. For example, the relief mural of the Monument to the People's Heroes, if it is not located at Tiananmen Square or is separated from Beijing, it may lose its own meaning, historical presentation and contemporary spiritual appearance. Therefore, the site selection of the monument was discussed at the beginning. Only in this environment can you appreciate the relief murals of the Monument to the People's Heroes, and it will be more appealing, as shown in Figure 4:

Figure 4. The relief mural of the Monument to the People's Heroes

As shown in Figure 4, the embossed murals reflect the function of the urban environment in addition to the above, but also reflect their own value, so that value and value can cooperate with each other. From a subjective point of view, relief murals mostly belong to the carrier of the urban environment, and they serve the urban environment. But even if it is to serve the environment, it cannot belittle the artistic value of the relief murals, otherwise it will cause people's feelings to be biased. Because blindly serving the environment not only reduces its own value, but also causes weightlessness. Therefore, if the city wants to use relief murals to form an artistic environment, it must carry out conscious mural creation. Of course, we must also integrate the people's aesthetic awareness and acceptance to create artistic works.

3. Experiment and Analysis

Before making sandstone relief murals, use colorimetry to classify the stones to make the color of the same wall converge. When carving, the design is divided into blocks according to the size of the mural design drawing to ensure the integrity of the mural [17]; the surface of the sandstone embossed murals has been scientifically treated with transparent colorless latex (acrylate latex) to protect the product from discoloration of the murals; the dry suspension method is used for installation, and waterproof sealant is applied to the joints of the blocks, and the water penetrates into the adhesive layer [18]. As shown in Figure 5:

Figure 5. Construction drawing of sandstone relief mural for exterior wall

As shown in Figure 5, the overall harmonious line reflects the need for mature use in the creation to match the architectural environment and theme requirements, so that the space and the shape are closely combined, which makes the overall shape complete and realize the harmony of the use of lines in the overall composition [19]. The relief murals of the Monument to the People's Heroes are very complete in the image composition of the characters, the appearance contours are undulating cleanly, and the lines are precise and not procrastinated. Not only did the lines not cause confusion, but they increased the sense of hierarchy, and each refined line was very clear. The lines used make the whole picture rich in decorative beauty, and the smooth direction of the lines makes the overall picture extremely dynamic. Coupled with the changes of the lines, the relief murals are more real, and people feel the harmony and unity of the natural world [20]. The overall layout of the relief murals is also very elegant, using realistic techniques to make the lines regular and follow, so that the whole picture is harmonious and unified, which let these organized pictures form a classic.

3.1. Composite Material Wear Test

It is difficult for a single alloy material to completely overcome the shortcomings of high temperature wear and cannot adapt to the matching of the hardness and toughness of the alloy material. This paper analyzes the interface structure and wear resistance of composite materials during the wear resistance test, and proves the advantages of wear resistance metal matrix composites through comparative analysis. As shown in Figure 6:

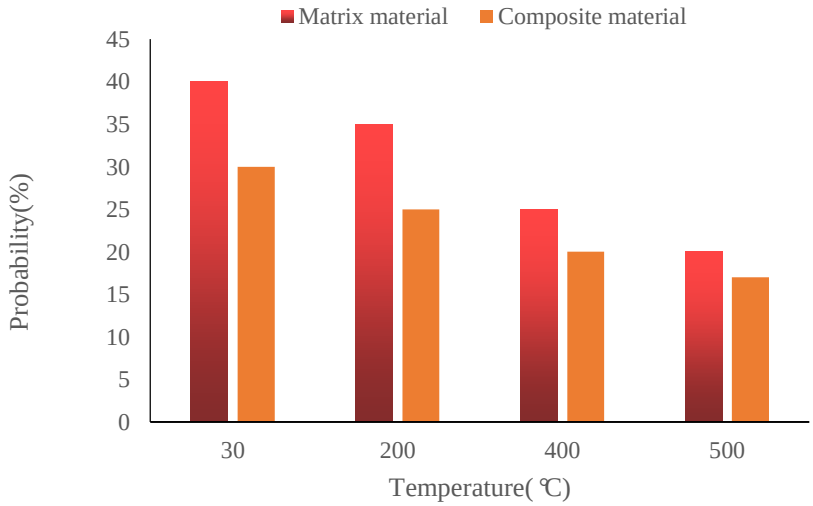

Figure 6. Test statistics graph of composite wear test

As shown in Figure 6. It can be seen that the wear resistance of metal matrix composites is better than pure metal materials at 30~500 ℃. When the temperature is 30 ℃, the wear resistance advantage is the largest, which is about 3.3 times that of the matrix. In fact, in the high-temperature wear process of the metal matrix composite material, the oxide film is destroyed before it plays a role in reducing wear. When the temperature rises, the area, density, and thickness of the oxide film increase, and the wear resistance effect becomes weaker. Therefore, the wear resistance advantage of the composite material is inversely proportional to temperature. Within 30~500 ℃, the wear resistance of the composite material is better than that of the base material, and the wear resistance advantage is inversely proportional to the temperature. The advantage is most obvious at 27 ℃, about 3.5 times that of the base material, and 1.5 times that of the base material at 500 ℃.

3.2. High-stress Three-body Abrasive Wear Test

Compare metal and metal matrix composite materials, wear tests were performed on the specimens under two loads of 4kg and 5kg, respectively, to calculate the amount of wear of different materials. Due to the different densities of the two materials in the composite material, the mass wear amount measured by the weight loss method is converted into the volume wear amount to analyze the wear resistance of the composite material more accurately, as shown in Table 1:

Table 1. Wear test table of specimens under two loads at 4kg

Wear time(min)	20	40	60	80
Composite material	0.675	0.567	0.786	0.465
Pure metal material	0.642	0.641	0.864	0.878

As shown in Table 1, it can be seen that when the wear time is 20 minutes, the mass loss and volume loss of metal matrix composites are slightly higher than those of pure metal materials; after the wear time reaches 60min, the wear volume of the metal matrix composite material in this 30min starts to be slightly lower than that of pure metal. Then the metal and metal matrix composite materials were subjected to abrasion tests on the samples under two loads of 5kg to more accurately analyze the wear resistance of the composite materials, as shown in Table 2:

Table 2. 5kg under two kinds of loads to carry out abrasion test on the sample

Wear time(min)	20	40	60	80
Composite material	0.1021	0.098	0.087	0.054
Pure metal material	0.1012	0.1005	0.1015	0.1123

As shown in Table 2: When the total wear time is 80 minutes, the pure metal material will be strengthened. The amount of wear of metal matrix composites is far lower than that of pure metal materials at the initial stage of wear. Although slightly higher than pure metal materials, as the wear time increases, metal matrix composites begin to withstand wear and protect the matrix, which makes their wear per 30min decline rapidly, showing far better wear resistance than metal materials . This is because the metal matrix composite material is mainly subjected to the main cutting in the early stage of wear, so the pure metal material shows better wear resistance than the composite material. In short, the wear resistance of metal-based composite materials is higher than that of pure metal materials, so metal-based composite materials should be used in the construction of relief mural exterior walls.

According to the above data, the total volume wear of the two sets of samples under different

loads are drawn, where 7-1 is the volume total wear diagram under 4kg, and 7-2 is the volume total wear diagram under 5kg load. It can be seen from Figure 7 that under a load of 4 kg, the amount of wear of pure metal materials increases with the increase of wear time, and the amount of wear of metal matrix composite materials decreases with the increase of wear time. The wear resistance of metal matrix composites continues to increase with the extension of wear time. As shown in Figure 7:

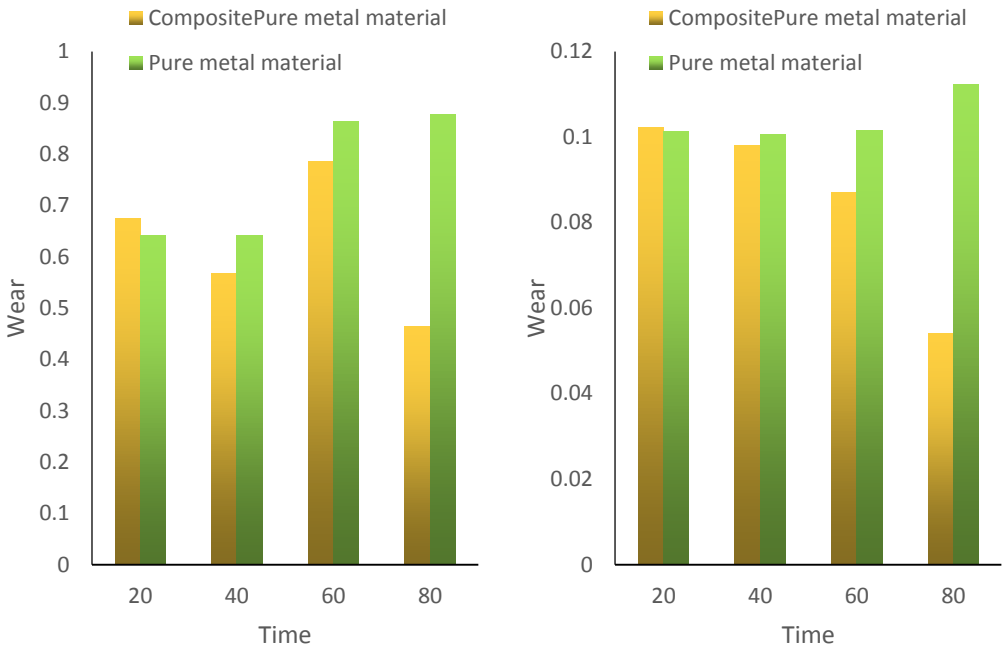

Figure 7-1. Volume total wear under a load of 4kg *Figure 7-2. Volume total wear under a load of 5kg*

Figure 7. Total wear amount graph

In Figure 7-1, the amount of wear of pure metal materials under load increases with the increase of wear time, and the amount of wear of metal matrix composite materials increases with the increase of wear time. That is to say, the wear resistance of the metal matrix composite material is 1.5 times that of high manganese steel under the wear condition of 80 minutes. In addition, it can be seen from Figure 7-1 that the longer the wear time, the more the relative wear resistance of the A metal matrix composite material will increase. However, comparing Figure 7-1 and Figure 7-2, it is found that the relative wear resistance of the composite material under a load of 5 kg is lower than that under a load of 4 kg. The lower the load, the higher the wear resistance of the metal matrix composite.

3.3. Questionnaire Method

In real life, most of the murals are suitable for other graphic art forms. The production process of three-dimensional art is different from that of graphic art. Three-dimensional art not only requires the length and width of the two-dimensional plane, but also needs from three-dimensional depth to more powerful modeling capabilities and modeling. This paper investigates whether metal materials

are used in the five sandstone relief murals on the market, as well as their service life and price, so as to determine the role of metal matrix composite materials in the construction, as shown in Table 3:

Table 3. Whether metal materials are used in the five sandstone relief murals

Survey object	Service life of pure metal materials	Composite material service life	Pure metal material price	Composite material price
A	5	10	45543	65367
B	7	14	54532	76474
C	6	14	65310	78901
D	8	13	78639	87955
E	7	15	65353	76556

As shown in Table 3: the five styles of murals using pure metal materials have a service life of about 6 years, while the service life of metal matrix composite materials is more than 13 years. From this perspective, the use of metal matrix composites is more in line with the needs of modern people.

Metal matrix composites have an extremely important position in traditional wear-resistant materials and are widely used. The main reason is that metal matrix composites have the characteristics of low production cost, excellent toughness and good deformation hardening ability. This article investigates the usage trends of metal matrix composites and pure metal composites from 2016 to 2019, as shown in Figure 8:

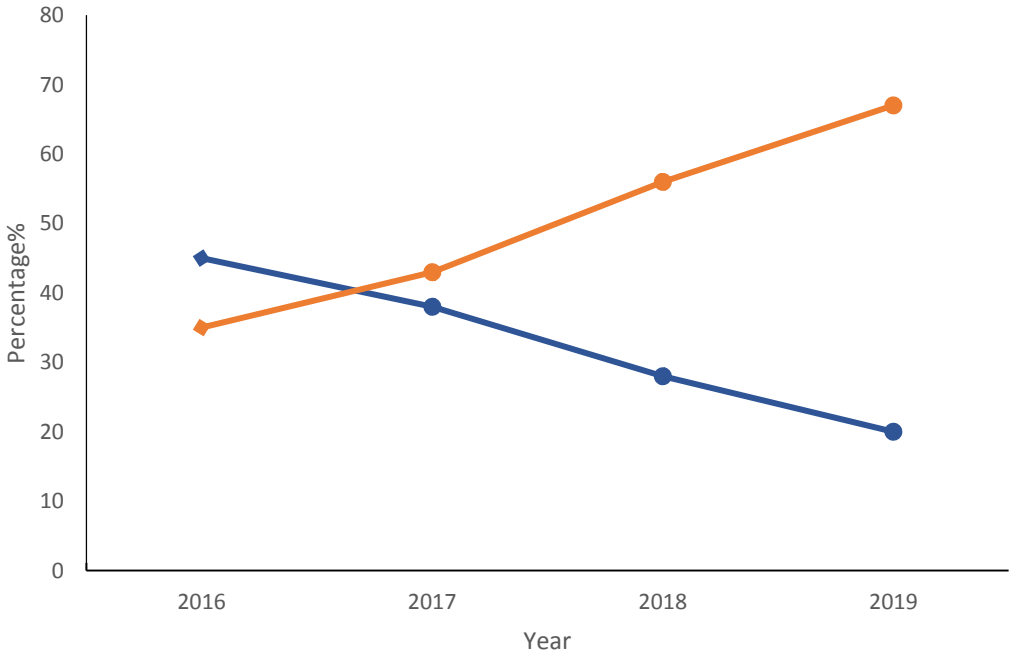

Figure 8. 016-2019 line chart of the trend of using metal matrix composites

As shown in Figure 8, the trend of using metal matrix composites has been rising up to 70% from 2016 to 2019, while the trend of using metal materials has been declining, as low as 13%. It can be seen that metal matrix composite materials are what the public needs. In summary,

improving the instability of wear resistance caused by the defects of pure metal materials is a major problem in the current industry. Therefore, metal matrix composites have become one of the main ways to improve the shortcomings of pure metals. The so-called composite material is a new material with a good combination of two or more materials with different properties prepared by a specific method. Metal is the matrix, and the second phase of the ceramic phase with greater hardness and strength is the reinforcement. The composite material that is generally used under the working conditions of wear resistance, corrosion resistance and heat resistance is called metal matrix composite material. It has become one of the development hotspots in the field of composite materials to improve the wear resistance of the metal matrix and reduce the industrial cost by adding ceramic reinforcing phases.

4. Discussion

Based on the knowledge of sandstone relief murals, this article is based on metal matrix composite materials to study how the wear resistance of metal matrix composites can play a role in the construction of sandstone relief murals. And how to reduce the cost, in the construction can not only be affordable but also extend the life of the work.

This article also uses the principal component analysis method, combined with various factors of the wear resistance of metal matrix composites, and learns how to play a role in the construction of sandstone relief murals by analyzing the use of metal matrix composites.

In this paper, through the abrasive wear test of pure metal and metal matrix composites, it is found that the wear resistance of metal matrix composites is better than that of pure metals, and the relative wear resistance of the composites is higher under low impact energy. The modeling features of the murals are integrated into the relief design, which not only inherits the traditional art, but also meets the retro aesthetic needs of contemporary people.

5. Conclusion

This article is based on the theoretical knowledge of sandstone relief mural construction, and based on the wear resistance of metal matrix composites, it is established that the wear resistance of metal matrix composites can play a great role in the construction of sandstone relief murals. Through the selection of various evaluation methods, the principal component analysis method is selected, and various algorithms are used to determine the role of the wear resistance of the base composite material, how to make the wear resistance of the metal base material play a role in the construction of the sandstone relief mural has become the central point of this article. In the experimental analysis, the wear resistance of pure metal materials and metal matrix composites was tested. Finally, it can be known that the wear resistance of metal matrix composites is higher than that of pure metal materials. Through the questionnaire survey, it is known that the trend of using metal matrix composite materials in the market has been on the rise in recent years. Therefore, metal matrix composite materials should be used in the construction of the external wall of the relief mural. Due to the author's limited research level and ability, this article still has certain deficiencies in the content, and further research is needed.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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