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PROSPECTS FOR THE APPLICATION OF INNOVATIVE SOLUTIONS IN THE DECORATIVE FINISHING OF SHOES

Han Jianlin[1], Gerasymenko Olena Dmytrivna[2]
[1] Postgraduate Student at the Department of Art and Fashion Design,
Kyiv National University of Technologies Design, Kyiv, Ukraine;
Shaanxi University of Science and Technology, Xi'an, China,
e-mail: 525586813@qq.com
[2]PhD in Design, Associate Professor,
Associate Professor at the Department of Art and Fashion Design,
Kyiv National University of Technologies and Design, Kyiv, Ukraine,
e-mail: gerasymenko.od@knutd.edu.ua, orcid: 0000-0001-8566-7215,
Scopus: 57474366800

Abstract. ***Purpose*** *of the article is to investigate innovative solutions for decorative finishing in shoe design taking into account ergonomic principles and to analyze the possibilities of combining aesthetics, functionality and practicality in the context of modern trends and consumer needs.*

Methodology*. The study used an interdisciplinary approach, which includes a literature review, structural and functional analysis of existing design options for ergonomic and aesthetically attractive shoes, interpretation and systematization of the results obtained.*

Results*. The article analyzes research aimed at improving the aesthetic and ergonomic qualities of footwear, which is developed in accordance with the requirements of individual consumer groups. It was determined that the introduction of innovative technologies of laser engraving, 3D printing, biomimetics and bionics methods improves the aesthetic qualities of shoes and satisfies consumer requirements in ergonomic design. It has been established that innovative solutions and approaches for ergonomic design is primarily widely implemented in the design of professional sports shoes, rehabilitation and orthopedic shoes, and military shoes. It has been determined that innovative ergonomic solutions can be integrated into shoes design, combining functionality with decorative finishes.*

Scientific novelty*. The work systematizes innovative approaches to the integration of ergonomics and decorative solutions into the design of various types of shoes. The possibilities of using bionic design and modern materials to increase the functionality and durability of shoes are identified.*

Practical relevance*. The results of the study are of practical importance for shoe designers and manufacturers.*

Keywords: design of shoes, ergonomic, decorative finishing, 3D printing, laser engraving, functionality, material innovation, bionics.

INTRODUCTION

With the improvement of people's living standards and the development of science and technology, the realization of ergonomic requirements in shoe design becomes more accessible for implementation in production. In footwear product design, more ergonomics issues such as comfort performance, hygiene performance, medical rehabilitation function, safety performance, etc. are integrated with art design and

aesthetics. In addition to considering basic practicality, fashionable and popular attributes, and social attributes of consumers, the design of modern footwear products has begun to appear to focus on the combination of design and ergonomics in order to seek high-level innovation.

A modern designer should summarize the changes and requirements of the corresponding design rules in order to make the design works meet to consumer demands and current fashion trends. Identifying innovative solutions and approaches to footwear design will ensure the development of shoes that are ergonomic, meet fashion trends, and combine aesthetics and functionality will increase consumer satisfaction, increase product value, promote technological progress in footwear design, and contribute to the achievement of ecological design practices.

ANALYSIS OF RECENT RESEARCH

Accompanied by the development of production technologies, footwear has evolved from its original functions of protection against cold and the external environment to fulfilling social and functional roles. Due to the wealth of decorative technologies and wide design possibilities, as well as the consideration that footwear supports the body's weight and facilitates basic motor activities such as walking and running, these aspects have become the object of intensive research by many researchers.

In the article [18], analysed women's shoe direction design since 2000 is studied, and the differences and characteristics of decorative changes are analysed in terms of a number of decorative aspects, such as shapes, materials, colours and fashion trends, so as to predict and indicate the direction of future women shoes' design. It is pointed out that «shallow shoes» can best reflect the image of women, and it is pointed out that shoes are designed from the perspective of aesthetics and on the basis of functionality or practicality as human nature. The study found that since the 2000s, shoes' design has begun to adopt future-oriented concepts, with a wider range of expression and more creative designs.

In the article by Wang C. C., Yang C. H., Wang C.S., Chang T.R. and Yang K. J. [15], stated that when conducting new product development for basketball shoes, both personal preference and commercial market value need to be considered, and the key is to combine both psychological and physiological aspects to design customised products for consumers. This study implements a feature-based morphing design process for basketball shoes design system from a perceptual perspective, using diverse shapes extracted from selected feature maps, which not only improves the design efficiency, but also greatly enriches the design diversity and degree of personalisation of basketball shoes.

In the scholarly paper by Wallace B. T. [14], analysed the customization of sneakers, and elucidates the various meanings participants attach to sneaker customization, as well as its implications within a broader socio-cultural context. It contributes to an understanding of everyday popular cultural practices by highlighting that the appeal of sneakers in contemporary culture lies in their dual function. On one hand, as symbols expressing identity and status. on the otherhand, driven by their consumption as emblems of style, masculinity, athletic prowess, or subcultural standing.

Researchers Hu J. [3] explored that as we age, our body functions deteriorate, especially the knee and hip joints, which can also limit our body's mobility, so it is important for the elderly to be guided by moderate exercise. His study was conducted to understand the needs of the elderly for sports footwear products. Based on the results of interview experiments and anthropometric data base, this study conducted a preliminary product design. An LED light bar with data transmission function is used to decorate and display the accumulated walking steps. At the same time, the LED light bar will emit different colours according to the number of steps recorded by the pedometer chip, which makes the product more interesting and makes the product both artistic and functional.

The research of Fernandes A. M. [2] is based on the integration of ergonomics and design, and the use of recycled and sustainable materials in the footwear industry to create products that are both innovative and ergonomic.

In the article by Liu P. P. and Huang H. Q. [7] based on ergonomic principles, this study analyzed the foot structure, physiological, and psychological needs of individuals with lower limb disabilities. It integrated ergonomic concepts into the design process to enhance footwear functionality regarding ease of wear (donning and doffing), comfort, stability, and protective qualities. The ergonomic design solution presented herein aspires to furnish this population with footwear that genuinely aligns with their foot structures and behavioral traits, ensuring comfort and health. Concurrently, this approach offers the market a more efficacious and practical design pathway, thereby contributing significantly to advancing and broadening its application scope.

Some research is being conducted on the sources of inspiration for creating clothing and footwear designs for adults and children. For example, in [11] the design of children's shoes inspired by the shape of animals is considered. Scientists investigate the use of various decorations in the design of clothing and footwear. Article [8] is devoted to the study of the use of decorative finishing of clothing in the collections of designers from different countries of the world.

PURPOSE

The aim of this work is to investigate the integration of ergonomic principles and decorative elements into the design of sports footwear from an interdisciplinary perspective. The main focus is on studying relevant design techniques and methods to create innovative, functional and attractive products that meet modern consumer requirements and current trends.

RESULTS AND DISCUSSION

Decorative elements and ergonomic elements represent two pivotal aspects in shoe design, embodying the artistic flair and functional excellence of these products. Decorative features draw from artistic and cultural dimensions, either appearing independently or integrating seamlessly with other elements, serving as a visually striking vector across the upper and sole. The decorative elements primary roles encompass: enhancing aesthetic appeal, reinforcing brand identity, fostering cultural and emotional connections with regional consumers, and shaping societal expressions of character.

Ergonomic elements, when incorporated into shoe design, prioritize functional enhancement. They may manifest as visibly distinct components complemented by decorative touches or as integral parts of a shoe's construction. Their chief objectives include: conforming to the human foot's anatomy and sports biomechanics for improved comfort, bolstering safety through enhanced support and stability mechanisms, optimizing hygiene via breathable, antibacterial, and odor-resistant properties, and elevating specialized athletic support, such as enhancing basketball shoes' torsion resistance and soccer cleats' braking capabilities.

The integration of ergonomic elements can help designers to improve the quality of the products in all aspects, increase the acceptance of the products in the market, and improve the added value of the products. To develop ergonomic solutions, designers should understand the basic structure of the bones of the foot and the characteristics of their movement. The bones of the foot are connected to each other in an arch-like structure called the arch of the foot. Those arranged in the transverse direction are called transverse arches and those arranged in the longitudinal direction are called longitudinal arches [5]. The foot relies on the structure of the arch and the attached ligaments to produce elasticity. When walking, bouncing or gravity presses down, the internal and external longitudinal arches press down, dispersing the force to the anterior transverse arch and the heel bone. The anterior transverse arch presses down, completing the dispersal of the force, and then the arch springs back, completing the cushioning effect [12].

Promoting the integration of decorative elements and ergonomic elements in shoes design can have the obvious effect of saving production costs, enhancing the added value of products and market competitiveness. By combining human body data with consumers' personalised decorative preferences, shoes can be designed to meet individual foot characteristics and reflect personal style, enhance personalised customisation and social attributes, comprehensively improve users' overall satisfaction and brand loyalty, and increase consumer stickiness. It can promote the integration and innovation of material science, manufacturing technology and formal aesthetics, so that the products stand out in the homogenised market and form differentiated competitive advantages.

Shoes and accessories change with the development of the times, economic changes, clothing and accessories, and trends and fashions. Shoes and accessories have experienced from basic protection and functionality to both aesthetic and functionality, to comfort and hygiene, and nowadays, shoes, boots and accessories have become diversified products, which are the conveyance of social attributes of personal aesthetic expression and sense of self-realization.

With the development of fashion trends and consumers' demand for personalization, decorative finishing in shoes has also seen diversified innovations, the common ones being carving, weaving, drip plastic, heat cutting, embroidery, foiling, rhinestoning, embossing, watermarking, laser engraving, hand embroidery, inlay, 3D printing, and so on. Decorative finishing and other increasingly advanced technologies can create complex structures to bring more artistic value and personalized design. In addition, the integration of ergonomics and rehabilitation medicine has also made some decorative and finishing parts of footwear and apparel products have certain functional assistance

and rehabilitation medical utility, bringing more added value while enhancing the appeal of the appearance of footwear and apparel products.

Among the innovative technologies and methods for producing relevant and functional design of shoes with decoration, laser engraving, 3D printing, and the use of bionic objects to create modern designs based on the principles of biomimetics are common.

The use of laser cutting technology can assist designers to engrave high-precision brand logos, patterns, complex patterns of geometric shapes on the surface of leather and other shoemaking materials, as well as to realize rapid hollowing out designs, which are both beautiful and practical [9]. For example, Balenciaga launched the X-PANDER (as shown in Fig. 1) sneakers in part of the upper design using laser engraving technology to shape a three-dimensional sense and a strong sense of modern structure, while the precision of laser technology to ensure the consistency of the process standards, reflecting the effective combination of technology and creative arts.

3D printing, also known as additive manufacturing, is a technology that builds the three-dimensional form of an object by stacking layers of material, and this new technology has a number of advantages. First of all, 3D printing technology enables the shaping of material shapes that are no longer dependent on moulds, allowing the creation of complex three-dimensional structures and personalised designs. Compared to mould applications, it reduces design costs and time consumption, and is particularly suitable for small batch or customised production, shortening time-to-market (as shown in Fig. 2). Secondly, 3D printing technology can realise almost any shape in space, providing designers with a very large degree of creative freedom, reaching technical heights that are difficult to achieve with traditional manufacturing, and promoting innovative design. Thirdly, 3D printing technology can be quickly customised according to consumers' foot shape, gait, plantar pressure and other parametric needs to meet the needs of different consumers and promote the added value of shoes product design.

Biomimetics or bionics is an innovative design methodology that draws inspiration from nature or other disciplines in human science to solve problems in the field of shoe design.

The basic concept of biomimetic design is to learn and imitate the workings and morphological patterns of the chosen object. One of its application rules is morphology bionics, which improves the appearance and functionality of sports shoes by imitating the form and structure of nature. For example, Nike's Air Jordan 13 model of sneakers (as shown in Fig. 3) is series of sports shoes is inspired by the cheetah's paw, aiming to offer better grip and flexibility. The second is functional bionics, which learns the function execution principle or process of an object and applies it to the performance design of sports shoes. For example, the bionic design of Adidas Sneakers ClimaCool (as shown in Fig. 4) series of sports shoes mimics the respiratory system of insects, enhancing the breathability and heat dissipation of the shoes.

In sports, we often come across footwear that incorporates ergonomic design ideas, such as many types of professional sports shoes [1]. To reduce the risk of sports injuries and facilitate the performance of physical injuries, shoes, especially sports shoes, use a shock-absorbing sole, which can reduce the risk of sports injuries [16]. The design of shoes largely depends on the design and appearance of the sole. For example, in Basketball shoes with cushioning (Fig. 5), the designer used the shape of a cloud to form the sole and design the decoration, taking the gentle ideogram of the cloud as an artistic inspiration, combining the softness and shock-absorbing effect of materials required for ergonomics with artistic material.

Fig. 1. Sneakers, model X-PANDER, Balenciaga

Fig. 2. Sneakers, model Godzilla, brand OGR

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Fig. 3. Sneakers, Air Jordan 13, Nike

Fig. 4. Sneakers, Climacool, Adidas

Fig. 5. Basketball shoes, Crazy BYW Icon 98, Adidas

Fig. 6. Fracture Rehabilitation Shoes, Ankle Brace, JW

Fig. 7. Boots, Fast-Tac 6" Desert Boot, 5.11 Tactical

In medicine, special footwear is often used in orthopedic and rehabilitation treatments for lower limb and foot surgery, and the design of these medical footwear has in-depth experimental information and results incorporated in ergonomics. For example, Fig. 6 shows a shoe used to assist in the treatment of foot bone fractures. The designers have adopted an exoskeleton form of construction and a mecha style for the decorative elements, presenting features that complement the artistic style of the exterior and the functionality of the shoes.

In the military field, soldiers often encounter different environmental conditions such as extreme cold, hot and humid, water flow etc. when performing various tasks. Shoes for the Air Force, Navy, and other specialized services have more specific needs [10]. So the design of combat boots needs to incorporate more ergonomics into the design. Desert Boot Fast-Tac 6" by 5.11 Tactical shown in Fig. 7 are also modelled according to the functional characteristics of the product and the environment in which they are used with the corresponding artistic decorative elements.

Along with the worldwide economic development and the improvement of human living standard [13], professional fitness, outdoor adventure, high-end medical rehabilitation, intervention orthopedics and other lives enter into the daily life of common people, and the special design of the above several special cases enters into the daily life, which becomes a necessary standard for the design of common footwear.

Accompanied by the rapid development of competitive sports and countries' investment in sports for all, athletic shoes have also stepped into the fashion world and people's lives from the athletic stadium, and become more artistic integrating the elements of athleticism, ergonomics and fashion [17]. Athletic shoes, a footwear product in the professional sense, have also risen in demand. In the manufacturing sector, the design of athletic shoes has become even more diverse.

The combination of specialization for various sports and ergonomics in the design of sports shoes provides athletes with maximum efficiency in the process of sports, and is also a powerful assistant for athletes in achieving the goal of «higher, faster, stronger», which has become an important symbol of modern innovative sports shoe design. In the process of the development of competitive various sports, athletes

are specialized in their own abilities, so the important sports equipment used in the training and events. So the athletic shoes also show the characteristics of specialization, and even the phenomenon of separating the same athletic shoes for the training from the shoes for the field of competition.

In terms of shock-absorbing footwear design, designers often use a number of biomimetic design solutions, such as curved, honeycomb structure, winding form, inflatable air cushion structure (as shown in Fig. 8) and so on. In this case, the bionic technique is often used to directly unify the form and function of the designed components [4].

Here we adopt a case study approach to analyze the «Li-Ning Bow» (as shown in Fig. 9) shock absorption technology designed by the famous Chinese sports brand «Li-Ning» [20]. The «Li-Ning Bow» shock absorbing technology is developed by utilizing the principle of relieving pressure by imitating the deformation of the arches of the human foot bones under pressure. The arch is the core component of the shock absorption function and has a very large deformation capacity. It is able to cushion the impact of the ground through appropriate deformation when the heel hits the ground. The core of the middle front part has superb toughness [19], the outer structure has superb elasticity, all of

Fig. 8. Sneakers, Zoom Soldier IV, Nike

Fig. 9. The «Li-Ning Bow» structure [20]

Fig. 10. Soccer shoes, Medusae Pro HG, Umbro

which provide perfect stretching ability for shock absorption deformation, and at the same time ensure the normal contraction of the Tensile, which plays a role in maintaining the durability of the overall structure. The PU component maximizes stability while ensuring shock absorption. The asymmetrical PU detailing on the heel is designed to maximize the stability of the heel when landing on the ground. The lateral extensions of the PU post and Arch on both sides play a key role in stabilizing the heel after landing. The perfect combination of the three components not only ensures the functional requirements of running, shock absorption and stability, but also realizes the technology that can be seen, touched and felt, and realizes the organic integration of ergonomics into the product design.

There is also a typical case of ergonomics being integrated into footwear design in soccer, such as design of soccer shoes for stopping the ball. The design of soccer shoes is aesthetically pleasing and requires spikes on the sole to enhance grip, an aspect that is well known to the general public [21]. On the other hand, soccer requires good stopping power on the top surface of the forefoot of the shoe, therefore, attention should be paid to the «shoe face», in order to quickly reduce the strong inertia of the soccer ball moving when it touches the shoe surface (as shown in Fig. 10). As the athletes need to minimize the air resistance in the process of sports, designers should pay attention to the whole top plate as much as possible in the process design of sprinting sports shoes [6]. The pattern design of the quilting process on the upper serves here as both a decorative design and an ergonomic functional design.

CONCLUSIONS

Decorative and ergonomic elements in footwear design are identified as key components that ensure the combination of aesthetics and functionality of the product. Modern technologies and methods for manufacturing relevant and functional footwear designs have been identified, such as laser engraving, 3D printing, and the use of bionic objects to create modern designs based on the principles of biomimetics. It has been established that ergonomic design using innovative solutions and approaches is primarily used in the design of professional sports shoes, rehabilitation and orthopedic shoes, and military shoes. However, today innovative ergonomic solutions, especially for cushioning, are also widely used in the design of everyday shoes.

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АНОТАЦІЯ

Хань Цзяньлінь, Герасименко О. Перспективи застосування інноваційних рішень в декоративному оздобленні взуття

Мета *статті полягає у тому, щоб дослідити інноваційні рішення для декоративного оздоблення в дизайні взуття з урахуванням ергономічних принципів та проаналізувати можливості поєднання естетики, функціональності та практичності у контексті сучасних тенденцій та потреб споживачів.*

Методологія. *У дослідженні застосовано міждисциплінарний підхід, що включає аналіз літератури, структурно-функціональний аналіз існуючих варіантів дизайну ергономічного та естетично привабливого взуття, інтерпретацію та систематизацію отриманих результатів.*

Han Jianlin, Gerasymenko O. D. (2025). Prospects for the application of innovative solutions in the decorative finishing of shoes. *Theory and practice of design. Culture and art*. 1(35). P. 421–429, doi: https://doi.org/10.32782/2415-8151.2025.35.45

***Результати**. У статті проаналізовано дослідження, спрямовані на покращення естетичних та ергономічних якостей взуття, яке розробляється відповідно до вимог окремих груп споживачів. Визначено, що впровадження інноваційних технологій лазерного гравіювання, 3D друку, методів біоміметики та біоніки підвищує естетичні якості взуття та задовольняє вимоги споживачів у ергономічному дизайні. Встановлено, що ергономічний дизайн із застосуванням інноваційних рішень та підходів у першу чергу широко впроваджується в дизайні професійного спортивного взуття, реабілітаційного та ортопедичного взуття, військового взуття. Визначено, що інноваційні ергономічні рішення можуть інтегруватися в дизайн взуття, поєднуючи функціональність із декоративним оздобленням виробів.*

***Наукова новизна.** У роботі систематизовано інноваційні підходи до інтеграції ергономіки і декоративних рішень у дизайн різних видів взуття. Визначено можливості використання біонічного дизайну та сучасних матеріалів для підвищення функціональності і довговічності взуття.*

***Практична значущість.** Результати дослідження мають практичне значення для дизайнерів і виробників взуття.*

Ключові слова: дизайн взуття, ергономіка, декоративне оздоблення, 3D друк, лазерне гравіювання, функціональність, інноваційні матеріали, біоніка.

АВТОРСЬКА ДОВІДКА:

***Хань Цзяньлінь**, аспірант кафедри мистецтва та дизайну костюма, Київський національний університет технологій та дизайну, Київ, Україна; Шеньсійський університет науки і технологій, Сіань, Китай, e-mail: 525586813@qq.com.*

***Герасименко Олена**, доктор філософії, доцент, доцент кафедри мистецтва та дизайну костюма, Київський національний університет технологій та дизайну, Київ, Україна, e-mail: gerasymenko.od@knutd.edu.ua, orcid: 0000-0001-8566-7215, Scopus 57474366800.*

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