Decorative Wood Veneers as a Medium for Contemporary Design: A Review

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The use of decorative wood veneers in contemporary design is increasingly emphasized as society becomes more aware of quality of life and environmental protection. This article explores in detail four key aspects of decorative wood veneers as a contemporary design medium: visual perceptual elements, multisensory interaction, sustainability and environmental impact, and technology and innovation. Through its unique aesthetic attributes and multisensory experience, decorative wood veneers enhance the aesthetics and user experience of interior design, respond to the global trend of sustainability, and promote innovation and environmental responsibility in the design industry through the use of environmentally friendly materials and advanced technologies. This article aims to provide insights for designers, researchers and related industries to stimulate further exploration of the application of decorative wood veneers in design innovation.

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INTRODUCTION

As the economy and lifestyles evolve, the home design sector is gradually leaning towards a development model centered on enhancing the consumer experience (Zhang *et al.* 2022). Under this trend, decorative wood veneers have become an important medium for contemporary design due to their unique aesthetic attributes, multi-sensory experience, sustainability and technological innovation (Ni 2016; Zanuttini and Negro 2021). The rich colors and diverse textures of decorative wood veneers provide natural beauty and a cozy atmosphere for interior design, while their natural touch and aroma enrich the user's sensory experience, enhancing the comfort and attractiveness of the space (Gui *et al.* 2012). In addition, as a sustainable resource, decorative wood veneers respond to the high demand for environmentally friendly materials in modern society, in line with the global trend of environmental protection. Advances in technology have expanded the range of applications for decorative wood veneers, allowing them to be adapted to a variety of design needs, from homes to commercial spaces to luxury vehicle interiors (Dumitrascu *et al*. 2013). These combined factors have made decorative wood veneers play a central role in contemporary design, not only meeting aesthetic and functional needs, but also promoting environmental responsibility and innovation in the design industry.

In the production of decorative wood veneers, visual physical quantities, such as texture pattern, colour, and gloss, as the final presentation form of the production results of decorative wood veneers, affect people's overall feelings and comprehensive impression of the relevant wood veneers products; thus they can play a crucial role in whether they can arouse the desire of users to buy them at a later stage (Huang *et al.* 2023). Aesthetically perceived design is another important aspect of research on decorative wood veneers, where specific colour ranges and saturation, as well as continuous and clear wood grain, can significantly enhance the aesthetic appeal of the wood (Dai *et al.* 2023), and where colour and grain design can also influence the visual experience by attracting the observer's attention and intensifying the texture levels (Huang *et al.* 2023).

As deeper research and growing awareness of nature conservation encourages producers, engineers, and designers to contribute to the rational and innovative use of raw materials, more and more studies are focusing on the environmental friendliness and sustainability of decorative wood veneers. The use of digital image-related technologies makes it possible to explore the influence of different production factors on the texture of decorative plywood finishes, by optimising the production process in order to reduce the possibility of material waste (Burnard *et al.* 2019). It is also possible to convert wood veneers residues, which are technically considered unacceptable, into decorative wall panels during the production process, and converting standard production residues can be engineered into an innovative, sustainable product that reduces damage to the environment (Mamić and Domljan 2023). Multi-sensory interaction research on decorative wood veneers not only focuses on visual perception, but also includes the comprehensive experience of multiple senses, such as touch and smell. By optimising the multisensory properties of wood veneers, the user experience can be significantly enhanced to meet the users pursuit of high quality living space (Razza *et al*. 2022).

Research into sustainability and environmental impacts is an important step in responding to the global Sustainable Development Goals (Stanescu 2022). The sustainable use of resources is promoted by improving the production and processing of materials to reduce resource consumption and environmental pollution. Technological innovation is a key driver of research and industry development in wood veneers materials. As market demand for wood veneers products becomes more diverse and personalised, technological innovation can provide diverse solutions to meet the needs of different consumers. This includes innovations in texture design through computer technology and performance improvements through material science (Hosseini and Peer 2022).

This article explores the multifaceted impact of decorative wood veneers as a design medium, specifically how it can be utilized through four key perspectives: visual perceptual elements, multi-sensory interactions, sustainability and environmental impact, and technological innovation. The articles aim to provide the design community with insights that demonstrate how the unique value of decorative wood veneers can be utilized for the advancement of modern design, as well as to stimulate further research and practical applications regarding their effective use.

DESIGN DIMENSIONS OF DECORATIVE WOOD VENEERS

Visual Perception Design Dimension

The visual perception dimension of design involves the scientific exploration of how humans perceive, interpret, and respond to the physical properties of their

environment through the visual system (Zhang and Chen 2024). By revealing individuals' processing mechanisms for visual information and their behavioral performance in specific environments, visual perception research provides theoretical foundations and empirical guidance for design optimization, product development, and environmental planning. Further research on visual perception can drive innovation in thin wood trim design and human understanding of the complexity of visual perception, leading to higher user satisfaction and environmental adaptability in interior design practice.

The uniqueness of decorative wood veneers in terms of visual perception is mainly derived from their natural color and texture. Their dimension of visual perception is focused on visual physical quantities such as texture pattern, color and gloss, with the aim of gaining a deeper understanding of how multiple attributes influence human aesthetic preferences, emotional responses, and behavioural decisions (Jin and Li 2023). Through different processing treatments, wood veneer can be used as a visual medium to convey the designer's ideas and style. In interior design, the color and gloss of veneer can modulate the atmosphere of a space and influence the emotional experience of the user.

In exploring the use of decorative wood veneers in contemporary design, the academic community has identified three core directions in visual perception research. First, research has focused on the visually perceived attributes of wood veneer materials, covering appearance properties such as color, texture, and gloss. These visual properties directly affect the effectiveness of wood veneer applications in design. In addition, there are studies focusing on people's attitudes and preferences towards various types of wood veneer products, *i.e*., aesthetic evaluations. This involves an individual's intuitive response to the aesthetics of wood veneer, including deeper emotional and psychophysiological responses. In addition, studies have explored differences in preferences between wood and non-wood environments, revealing higher acceptance and preference of wood environments among audiences (Li *et al.* 2021). The surface visual properties of wood, such as grain, knots, and wood colour, are key factors influencing people's preference evaluations of wood materials (Strobel *et al.* 2017). At the same time, it has also been noted that factors, such as wood species, form of application, knot characteristics, and spatial location contribute to consumers' evaluative preferences for wood materials (Nakamura 2012; Jalilzadehazhari and Johansson 2019). These research directions provide an important theoretical foundation and practical guidance for the innovative application of decorative wood veneers in contemporary design.

Color and key physical attributes of restructured decorative wood veneers are visual information initially perceived by the human eye and play a crucial role in shaping the human viewing experience. Masuda (1985) provided a historical perspective, investigating the effects of color and gloss on wood images. Lindberg *et al*. (2013) used product semantics to identify three key dimensions for assessing the visual perception of wood: exclusive-modern, ecofriendly-natural, and light. It has been further shown that these perceptions are consistent across the senses (three different modalities of seeing, auditioning, and touching). Color can have an impact on the mental image of wooden interior environments (Fujisaki *et al.* 2015). The aesthetics, contact comfort, and air humidity regulation of wood materials are of great value in enhancing the physiological and psychological well-being of the space (Kotradyova *et al*. 2019). Clear, bright and warm wooden environments are preferred for cognitive tasks, and wooden indoor environments produce more positive emotions and less fatigue (Zhang *et al*. 2016; Poirier *et al.* 2019). Wood colour and coverage significantly influenced the aesthetic assessment of wooden office spaces (Zhu *et al.* 2023), and wood in daylight interior spaces and wood surfaces in

the built environment were associated with enhanced well-being and comfort, respectively (Watchman *et al*. 2017). These psychological perceptions can be linked to the physical properties of wood (Strobel *et al.* 2017). further emphasizing the role of wood materiality in creating a specific atmosphere in architectural spaces (Jafarian *et al*. 2018). The current evaluation dimensions of the visual perceptual characteristics of decorative wood veneers from a visual point of view include: surface color texture (color), surface texture pattern (grain), surface gloss (light), application product shape (shape), application category characteristics (proportion, etc.) and other visual factors (Fig. 1).

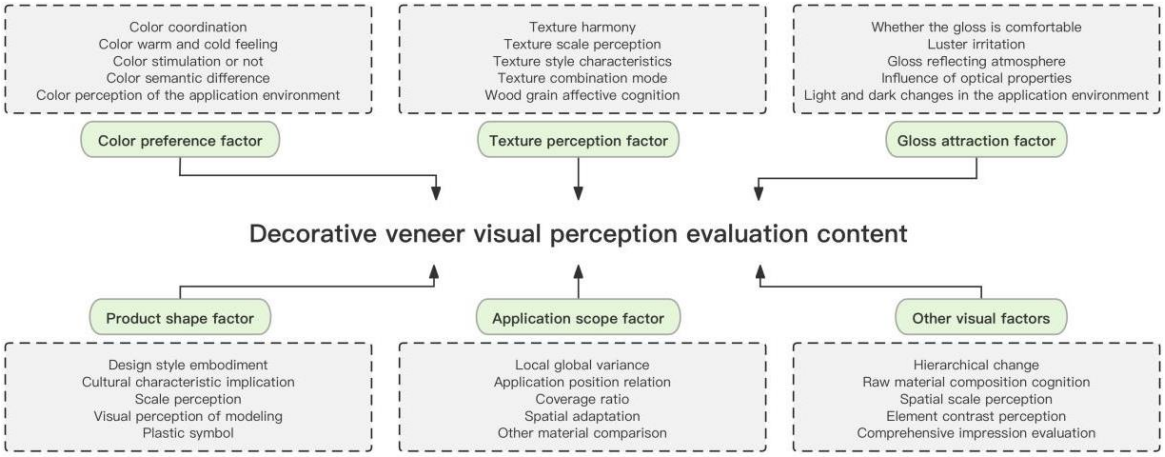

Fig. 1. Evaluation dimensions of visual perceptual properties of decorative wood veneers

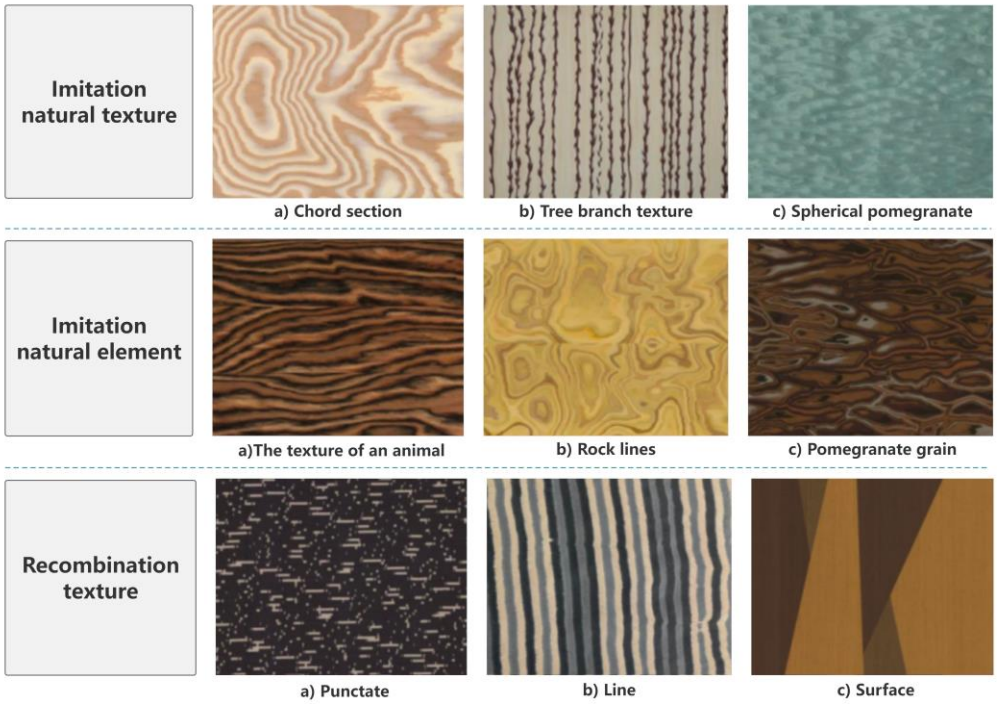

Fig. 2. Types of decorative wood veneers textures

In the production process of decorative wood veneers, the texture is usually produced through four processes: planing, three-dimensional reorganization, secondary reorganization and angular planing. The formation of a complex texture type is initially

based on simple geometric shapes, and then reorganized. At present, decorative wood veneers can be divided into three types of texture: one is to imitate the natural wood grain embodied in the wood itself; the second is to imitate the natural elements as the source of the texture; the third is to belong to the surface of the home decorative modeling texture, as shown in Fig. 2 (Huang *et al.* 2023).

The texture composition of decorative wood veneers follows the principle of planar composition, with points, lines, surfaces and other basic elements in a variety of arrangements or combinations. From the surface, geometric texture with its regular basic shape and unique visual expression forms a sharp contrast with the natural elements represented as random (Fig. 3).

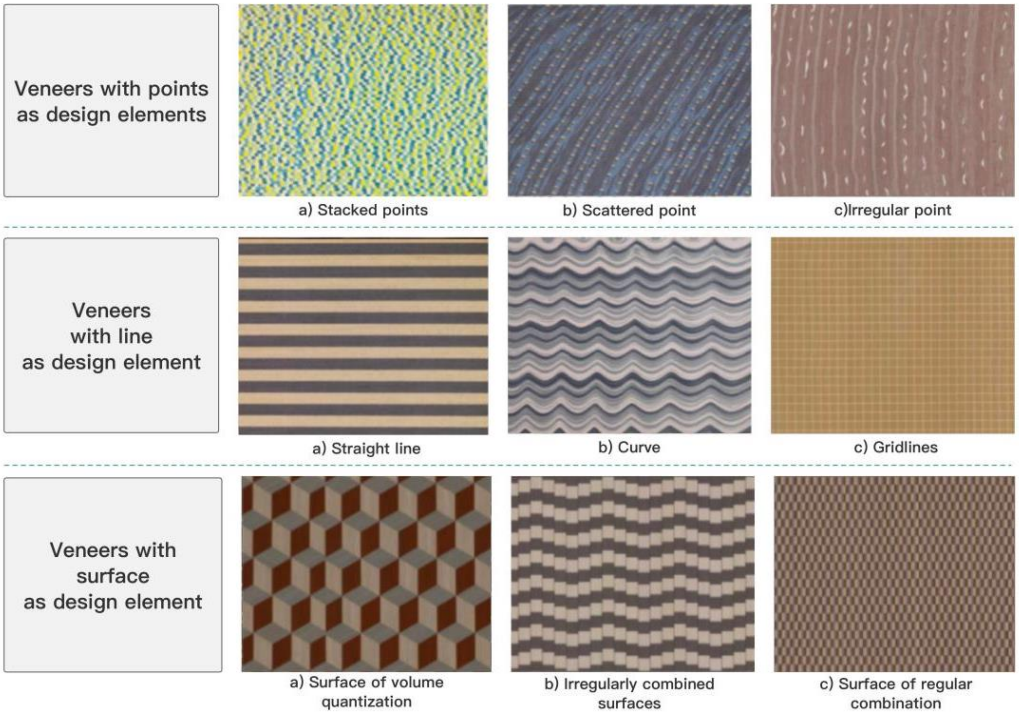

Fig. 3. Grain composition of decorative wood veneers

The surface gloss, light reflection properties, and anisotropy of wood give it a variable visual effect. It has been found that the interactions on the surface gloss of different wood species can produce the visual impact desired by the user, thus creating a lighting atmosphere that improves the quality of the interior space. Komeyama *et al*. (2016) tested the contrast difference of wood trim surfaces due to painting with the help of an eye movement technique and showed that there is a correlation between the texture clarity under the influence of a coating sheen and the attractiveness and contrast values of wood trim surfaces. Bekhta *et al.* (2014, 2018) found that the number of lacquer layers and the amount of lacquer applied significantly affected gloss, and that thermal compression of birch and that the densification of various woods enhanced gloss. Fekia (2016) further noted that the type of clear coat, the number of coatings, and the method of finishing the wood surface all affect gloss. Gloss can affect the perceived image of the wood, and transparent coatings on the surface of wood increase gloss and create images of "flare" and "tarnish" (Masuda 1985; Peng and Zhang 2019).

Multi-sensory Interaction Design Dimension

Multi-sensory perception is gaining widespread attention as an important perspective for evaluating and experiencing the use of wood. Decorative wood veneers provide a comprehensive perceptual experience in design through their unique materials and textures. This experience is not the stimulation of a single sense, but the joint action of multiple senses, creating a richer and more three-dimensional perceptual effect (Spence 2020).

Decorative wood veneers can interact with users through multiple senses such as vision, touch and smell, stimulating their emotional resonance and providing a comprehensive and rich sensory experience. This also provides designers with new creative and expressive methods, promotes the innovative application of decorative wood veneers in modern design, and breaks through the limitations of traditional design (Schifferstein and Desmet 2008).

Recent studies continue to reveal the important role of the senses of touch, smell, and vision in the design evaluation of wood products, and these studies provide new perspectives for understanding and evaluating the design of wood and its decorative applications. By exploring cross-modal coherence in natural objects, researchers have revealed the existence of significant positive correlations between vision, hearing, and touch. This finding emphasizes that the senses work in concert to perceive the world around us in natural environments, providing insight into how decorative wood veneers can be perceived and evaluated through multiple senses (Kanaya *et al*. 2016). Haverkamp's (2017) study focused more on the role of tactile sound in the perception of material properties and quality perception. The data suggest that tactile sounds generated by sliding a finger across a surface contain important information about material properties and quality. This implies that tactile sound is a factor that cannot be ignored, when selecting and designing materials with multisensory harmony. Fujisaki *et al.* (2015) explored the perception of material properties of wood through three different modalities: visual, auditory, and tactile, and found that wood's affective properties behaved similarly across all three senses, demonstrating that wood's emotional material properties are characterised at least to some extent in a hyper-modal manner.

Based on this understanding, the research methodology evolved, expanding from simple physiological and psychological evaluation metrics, such as heart rate and blood pressure, to the use of advanced technological tools, in the forms of eye tracking, electroencephalography (EEG) analysis, and skin conductivity measurements in order to more accurately capture and describe the nuances of the multisensory perceptions of the responses to the visual properties of wood.

Perceptual imagery mining based on physiological signals is a hot research direction in recent years. Human physiological signals are mainly regulated by the autonomic nervous system, which can effectively reflect the degree of human stress response.

When evaluating people's physiological responses provoked by the visual properties of wood-based materials, commonly used indicators include brain activity, autonomic nervous activity, endocrine activity and immune system activity, as shown in Table 1 (Burnard and Kutnar 2015).

Table 1. A Compendium of Relevant Literature on Each of the Sensory Dimensions

Sensory analysis	Indicator data	Conclusions	Reference
Visually	Alpha and gamma waves of electroencephalogram (EEG)	Alpha and gamma waves identify 3D color and shape preferences	Chew *et al.* (2016)
	Pupil diameter	The user's pupil diameter dilates in response to aesthetically pleasing visual stimuli	Kuchinke *et al.* (2009)
	EEG gamma wave	Gamma-wave band fluctuations are associated with the processing of physical features of the stimulus such as color and form of representation	Gerber *et al.* (2017)
Haptic	EEG theta wave	Significant correlation between theta wave variation and subjective sensory evaluation and physical properties of fabrics by subjects	Jiao *et al.* (2020)
	EEG alpha wave	The intensity and range of alpha waves were significantly and positively correlated with the subjective evaluation of fabric softness and physical indexes.	Zhang *et al.* (2016)
	EEG alpha and beta waves	Alpha waves are lateralized according to tactile stimuli, and systematic modulation of beta waves reflects tactile vibrational frequency	Spitzer and Blankenbur (2011)
Olfactory	EEG alpha wave	Prefrontal alpha wave asymmetry in the brain correlates with pleasurable emotions experienced by users during olfactory stimulation	Di Flumeri *et al.* (2016)
	EEG alpha and beta waves	Increases in alpha and beta waves following olfactory stimulation indicate that the odor has anti-stress and relaxation effects	Murao *et al.* (2013)
	EEG alpha and beta waves	An increase in the alpha/beta wave ratio indicates that the odor gives physiological relaxation	Ikei et al. (2015)

Early studies on the relationship between wood materials and human physiological state have used blood pressure, heart rate, pulse rate, *etc.*, as physiological evaluation indicators. Both Sakuragawa *et al.* (2008) and Tsunetsugu *et al.* (2002) combined human heart rate, blood pressure, and subjective evaluation indicators to study that people in the same space in the face of wood decorative background wall, blood pressure than in the face of other materials background wall has a significant reduction in the negative emotions more alleviated. With the development of science and technology and research methods, researchers are able to understand people's visual perception and cognitive processing of wood materials more deeply through eye movement technology. Kato and Nakamura (2016) evaluated the light reflection properties of wood materials from the perspective of illumination, synthesising eye-movement experiments, and perceptual engineering methods in an attempt to elucidate the relationship between wood gloss contrast and user intention evaluation. In addition to the aforementioned determination of visual perception through the collection of eye movement and EEG physiological signals, physiological

indicators, such as skin conductivity, salivary cortisol, heart rate variability, *etc*., are now gradually becoming evaluation indicators for the determination of visual perception of wood materials, whilst infrared-based non-contact perception measurement methods are also being further developed (Kimura *et al.* 2011).

Sustainability and Environmental Impact Design Dimension

Sustainability and environmental friendliness are important factors that cannot be ignored in contemporary design. The renewability and low environmental impact of decorative wood veneers as a natural material makes it an ideal choice for green design materials (Yuan and Tang 2021).

Sustainability design research in decorative wood veneers is dedicated to the development of environmentally friendly production methods that are in line with the Sustainable Development Goals (SDGs) by reducing CO_2 emissions and contributing to ecological civilization (Xiong *et al.* 2022). Further improve product performance and durability for integrated environmental, economic and social sustainability. Decorative wood veneers are highly regarded for their eco-benefits, the use of decorative wood veneers in the furniture industry and interior design reflects its environmental and economic benefits, and its development, characteristics and current status of application are studied and analysed. The promotion of this material is seen as a step towards more sustainable and cost-effective furniture production (Zhou *et al.* 2022).

The production of decorative wood veneer reduces damage to forests by efficiently utilizing wood resources, while increasing the efficiency of material use. Compared to other materials, the production process of decorative wood veneer has lower energy and water requirements, helping to reduce the overall carbon footprint (Chen *et al.* 2021). As a renewable resource, the biodegradable nature of decorative wood veneer is consistent with the principles of a circular economy and reduces the burden on the environment, as shown in Fig. 4 (Velenturf and Purnell 2021).

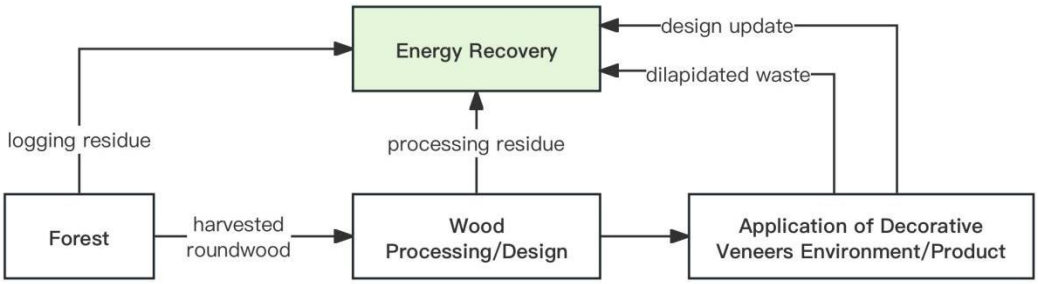

Fig. 4. Schematic flow diagram of biomass in the life cycle of decorative wood veneers

The current environmental quality of indoor space has become a problem that cannot be ignored (Mujan *et al.* 2019). Decorative approaches to interior spaces should begin with the application of natural colors and natural materials, organically combining green materials and green decorative design in order to create an interior space where health and comfort go hand in hand (Xu and Zhang 2022). In exploring the sustainability research and practice of decorative thin wood, designers and researchers are committed to achieving the common goal of sustainable development in the interior design industry (Cui *et al.* 2022), and the process of moving from theory to concrete application reveals a development trend that is driven by deep-seated environmental awareness and

technological innovation (Yang *et al.* 2015). Waste wood can also be transformed into new materials with decorative and functional properties. The process of transforming oak waste into decorative wood wall panels reduces wood waste and environmental damage, deeply integrating sustainability into the design and production process.

The realization of sustainability goals has become more feasible through technological advances and innovative designs, and design research on decorative wood veneers offers new directions and potential for the furniture manufacturing and interior decorating industries. Future research needs to continue to explore how wood and its products can be further advanced in terms of environmental friendliness and sustainability through more innovative technologies and design concepts, providing greener and more environmentally friendly material choices for the construction and decoration sectors.

Technology and Innovation Design Dimension

In recent years, technological and methodological innovations in the field of decorative wood veneers have focused on improving the functionality, aesthetics, and environmental friendliness of wood products (Liu *et al*. 2019). Technological innovations have further enhanced the functionality and aesthetic value of veneer, adapting it to the modern design's pursuit of high quality, environmental protection and personalization, and making it an indispensable and important part of contemporary design.

First, research has shown that the performance of wood veneers products can be significantly improved through the use of novel materials and advanced treatment technologies. Thermally modified treatment technologies have been widely used to improve the stability and durability of wood veneers products (Feng *et al*. 2022). Khsanshin *et al.* (2018) developed decorative composite panels with the natural color of valuable tree species through thermally modified dyeing technology, which enhanced the physical properties of the composite panels, as well as reducing the use of chemicals, realizing the dual advantages of environmental protection and functionality. The use of wood polymer composites as adhesives for attaching finishes offers the possibility of replacing formaldehyde-based adhesives, providing new perspectives on improving wood utilization efficiency and reducing environmental pollution (Arya *et al.* 2023).

Second, improving the aesthetics and utility of thin wood trim can be achieved through new manufacturing processes and modification methods. Mamić and Domljan (2023) developed decorative wall paneling products through the innovative application of oak cutting residues, demonstrating the versatility and innovation of decorative wood veneers design. Laser-cut veneer lamination (LcVL) takes advantage of laminated object manufacturing and plywood technology to achieve efficient manufacturing of complex geometries (Tao *et al.* 2020).

The use of bio-based materials and nanotechnology has opened up new opportunities for decorative wood veneers design. Mycelial composites reinforced with wood veneer can integrate continuous wood fibers using a robotic additive manufacturing process (Özdemir *et al.* 2022). Meanwhile, the novel nanoscale coating technology developed based on the sol-gel process effectively solves the problem of light-induced color change, further enhancing the aesthetics and durability of thin wood products (Kirilovs *et al.* 2015). In addition, EVA films can be innovatively used as adhesives and reinforcing materials to create flexible decorative wood veneers, solving the problems of traditional wood veneers that are prone to cracking and poor flexibility (Zhang *et al.* 2023a,b). These approaches extend the range of wood applications and enhance the structural properties of wood veneers. Wang *et al.* (2020) prepared wood veneers with the

dual functions of EMI shielding and decoration by simple chemical copper plating, which provides more multifunctional application possibilities for wood. The possibility of more versatile applications is provided. Research on the potential sustainability effects of wood in automotive applications points to the fact that realizing the use of wood in advanced manufacturing can promote environmental, social and economic benefits (Mair-Bauernfeind *et al.* 2020). Empirical studies have found that new technologies in the asymmetric veneering process of wood-based panels significantly improve the quality of products sold, which proves the important role of technological innovations in enhancing the competitiveness of products in the market (Więckowska and Grzegorzewska 2019).

CONCLUSIONS AND PROSPECTS

Decorative wood veneers play a crucial role in modern design, and research into their visual perceptual properties, multi-sensory interactions, sustainable designability, and technologies, and innovations reveal their multi-faceted applications in the visual arts and interior design. The visual properties of decorative wood veneers, such as color, texture and gloss, not only directly shape people's perceptual and emotional responses, but also enhance the sensory richness and attractiveness of the design through interaction with the senses of touch and smell. The environmental attributes and high resource efficiency of decorative wood veneers demonstrate their sustainability benefits, which are closely linked to the global goal of sustainable development. Technological innovations are driving up the performance and environmental standards of decorative wood veneers products while opening up new possibilities to enhance their practicality and aesthetics, fulfilling the dual need for innovative design and future sustainability.

As an important medium in the field of contemporary design, decorative wood veneers have demonstrated their comprehensive potential in terms of utility, aesthetics, and environmental friendliness, but their design research and practice also face multiple challenges and limitations.

In terms of multisensory design applications, how the multisensory properties of decorative wood veneers can be accurately measured and applied remains a research challenge. Currently, there is a need to develop and standardize new assessment tools and integrated technologies, such as the use of virtual reality and augmented reality to simulate and optimize the sensory impact of wood veneer in different design environments. In addition, the establishment of industry standards and guidelines is important to promote the practical application of multisensory design.

From the perspective of technology implementation and cost-effectiveness, although innovative solutions such as bio-based materials and nanotechnology can significantly enhance the functionality and environmental attributes of decorative wood veneers, the high cost and difficulty of implementation of these technologies limit their widespread adoption. To address this challenge, research should focus on developing more cost-effective production methods and exploring policy incentives to facilitate market penetration of these advanced technologies.

Although decorative wood veneers have strong environmental properties, sustainable management of the full life cycle remains a challenge. This requires strict regulation of wood sourcing, treatment, and final disposal from source to end. Promoting supply chain transparency and legality certification of wood sources, as well as developing eco-friendly design and recycling technologies, are critical to enhancing the market

competitiveness and acceptance of decorative wood veneers products. In addition, increased consumer awareness of the environmental value and technological advantages of decorative wood veneers products is critical. This requires demonstrating the environmental benefits and design potential of decorative wood veneers through education and marketing campaigns, especially utilizing digital marketing strategies and social media platforms.

By synthesizing these strategies and solutions, decorative wood veneers research and applications will become more sophisticated, providing more sustainable and innovative solutions for contemporary design and meeting modern society's need for high-quality and eco-friendly living spaces.

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