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DESIGN OF A MULTIFUNCTIONAL WOODEN HAIR ACCESSORY

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Abstract: The aim of this study is to present the design process of wooden, multifunctional hair ornaments from the initial concept through prototype production and testing. Hair ornaments are objects that simultaneously serve aesthetic and functional purposes for the wearer. The research begins with a historical and cultural overview, with particular emphasis on the meanings associated with hairstyles and animal motifs. During the design process, motifs from medieval Japanese and Viking cultures, as well as ancient Egyptian culture, inspired the forms. Based on the results of the motif research, freehand sketches and the CAD models derived from them are presented. The necessary modules of the Solid Edge 2024 software were used to create the models. Ergonomic considerations were taken into account to a great extent in the designed models, and their suitability was tested through FDM 3D printing. The hair accessory prototypes were produced using a computer-controlled milling machine and steam bending techniques. The results present an innovative product concept that, depending on the motif, can be used as a hair ornament and massage comb, while in another motif it can also function as a bracelet and hairband.

Keywords: *product design, wooden hair barrette, wooden hair pin, hair accessory*

1. INTRODUCTION

The objective of the presented research is to describe the design process of a multifunctional hair ornament that can be used as a hair accessory when fixed with a hairpin, and independently as a massage comb. An additional important starting condition is that the ornament must be made of wood, keeping in mind the importance of the circular economy.

Hair care has always played a significant role in human life. Aimé Bocquet and Michael Noël demonstrate that combs were already produced in the Neolithic period.

These were made of boxwood; the teeth of the combs were carved using flint tools, and polishing was carried out with sand or sandstone (Bocquet & Noël, 1985).
Norbert Haas, Françoise Toppe, and Beate M. Henz stated that the beauty and strength of hair were of great importance in both Ancient Greece and the Roman Empire. In these cultures, hairstyles were strongly influenced by religious beliefs, social affiliation, and rank (Haas, Toppe, & Henz, 2005).
Hoda Abd Allah Kandil and Mahmoud El-Mohamdy Abdelhady Salama discuss the hairstyles and hair-care practices of ancient Egyptians. Despite the widespread use of wigs by both women and men, natural hair was not neglected. Hair was regularly washed, treated with creams, and combed to remove insects (Kandil & El-Mohamdy, 2018).
At the beginning of the design process, after examining historical periods, contemporary hair-care tools also had to be studied in order to achieve appropriate results. The research focused on the following elements:

- hairpins,
- hair ornaments,
- combs,
- and so-called “gua sha” massage combs.

Gua sha originates from traditional Chinese medicine, where it was applied somewhat differently than in its modern interpretation. The word “gua” means scraping, while “sha” was used in Chinese medicine to describe acute illnesses. At that time, it was applied to the shoulders and back. Through rubbing and scraping, deep marks were created on the patient’s skin to stimulate blood circulation and relieve stagnation in tissues. However, modern medical science has found no evidence of its therapeutic effects.
The product to be designed is primarily a wellness product rather than a medical device. It is used for scalp massage and is associated with several positive effects: reduction of pain, swelling, and wrinkles; relief of stress and tension; and support of hair growth. Its design meets ergonomic requirements: it feels pleasant in the hand and ensures smooth, gentle movement on the scalp (Dubinskaya, Yurova, & Vvedenskaya, 2024).
Market research revealed products featuring animal motifs. In these cases, the animal’s body formed the handle of the comb, while the animal’s legs or tentacles represented the comb teeth. The forms of massage combs were shaped into creative designs while retaining their function. This led to the idea that, when designing hair ornaments, the hair-care traditions of different cultures and their characteristic animal motifs should be taken into account.

From a design perspective, three cultures and their significant animal motifs were selected. The symbols of these cultures are highly distinctive and are associated with numerous legends. The chosen cultures are: Japan and the fox, Egypt and the uraeus serpent, and Viking culture and the Odin's two ravens.

In Japanese culture, the "kitsune" fox is regarded as a mystical, cunning, and magical creature. Brenda G. Jordan collected legends in which foxes appear as supernatural beings (G. Jordan, 2013). According to folklore, the kitsune is a fox capable of taking the form of a woman and deceiving humans, as can be seen in Figure 1.

Figure 1. *Fox in human form (G. Jordan, 2013)*

Jack A. Josephson presents the significance of the uraeus serpent motif throughout different historical periods (Josephson, 1992). In ancient Egypt, hairstyles held particular importance, expressing the wearer's social status and wealth. In this culture, the uraeus serpent appears in various forms: as part of gods' headdresses, on statues, and in wall paintings. Figure 2 shows Nectanebo I. with the uraeus serpent on his headdress. The serpent symbolizes royal protection and power.

Figure 2. *Statue of Pharaoh Nectanebo I with the uraeus serpent on his headdress (Josephson, 1992)*

In Combs and Comb Making in the Viking Age and Middle Ages, Dan Carlsson discusses not only the placement of combs in burial sites but also the respect accorded to the craft of comb making (Ambrosiani, 1981). In medieval Viking culture, alongside hair care, the symbol of the twin ravens (Huginn and Muninn), who accompanied the god Odin everywhere, was of great importance (Sayers, 2022). The two ravens can be seen on Figure 3.

Figure 3. *Viking ravens (Huginn and Muninn)*
https://en.wikipedia.org

2. THE DESIGN PROCESS

In the following chapters, we present the main steps of the design process through a selected character (fox, ravens, snake). Each major step is discussed in greater detail in a separate subchapter.

2.1. Motif research, form design

The form design phase was carried out using freehand sketches, paper study models, and 3D design. In the fox form, the animal's legs became the teeth of the comb, while the characteristic shape of the fox's tail formed the decorative handle of the hairpin. By enlarging the paws, the "massage spheres" commonly found on massage combs were created. The design process is illustrated in the images in Figure 4.

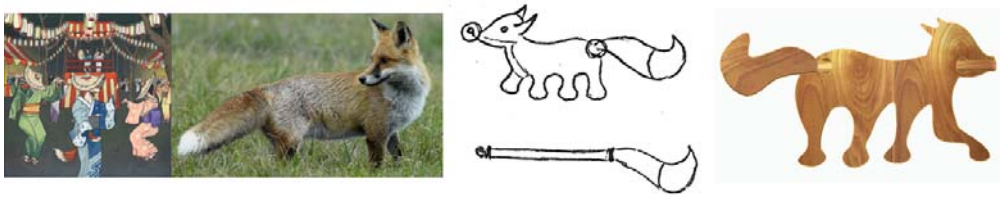

Figure 4. *Transformation of the fox motif into a massage comb form*

The snake form appears in Egyptian headdresses in several representations resembling an infinity motif. By rotating and multiplying the infinity symbol, a hair ornament can be created that is also usable as a bracelet and massage comb. The ouroboros motif –a snake biting its own tail– is also related to this concept. Throughout the design process, continuous attention was paid to functionality to ensure the product met all intended uses. The design process of the uraeus is illustrated in the images in Figure 5.

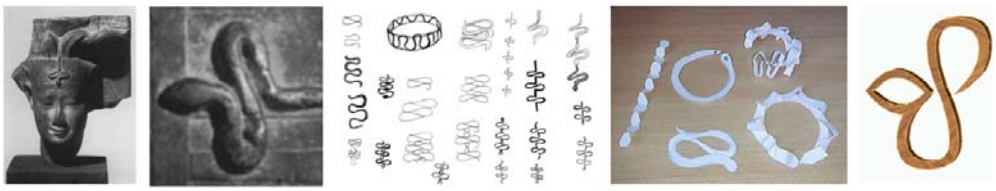

Figure 5. Transformation of the uraeus serpent motif into a hair ornament

In the case of the Odin's two ravens, the two parts complement each other to form a complete shape, while also allowing for separate use. The end of the hairpin reflects the tapering triangular shape of the ravens' tail feathers and incorporates a characteristic Viking symbol: the Celtic knot. The process can be seen in Figure 6.

Figure 6. *Transformation of the Viking raven motif into a hair ornament*

2.2. Prototype manufacturing

The first demonstration model (mock-up) was produced using 3D printing technology. An Ultimaker 3 FDM printer was used, with green TPLA material. The CAD model was converted into a printable file using the Cura slicing software. This resulted in the first fox hair accessory prototype, which was ideal for testing and can be seen in Figure 7.

Figure 7. *First mock-up model*

While the overall form and dimensions met the requirements, several functional issues were identified. The most significant shortcoming was the internal volume enclosed by the hairpin and the ornament, which was insufficient to hold a larger

amount of hair. As a result, it was not suitable for all hairstyles: for example, it worked in braids but could not secure buns or ponytails. The spacing and rounding of the teeth were satisfactory. The product functioned as a hair ornament, a high-precision styling comb, and a massage comb.

a)

b)

c)

d)

Figures 8–11. *Comparison of volumes, hairpin lengths, mock-up models, and hairstyles*

Due to these shortcomings, further design refinement was carried out, resulting in an improved prototype. In the second prototype, the internal volume between the hairpin and the ornament was increased by offsetting the holes, which required adjusting the length of the hairpin accordingly. This version accommodated a wider range of hairstyles and provided greater stability. The final result was an attractive hair ornament capable of securely holding hair and enabling quick hairstyle creation. The process can be seen in Figure 8.

2.3. Manufacturing technologies

Two possible manufacturing approaches were considered. Since the hair ornament must be made of wood, one option was CNC milling, while the other was laser cutting.

The advantage of CNC milling is its high precision and smooth surface finish as can be seen in Figure 12. Its disadvantages include long production time, significant material waste, the need for specialized expertise, and extensive post-processing. The wooden prototype was produced on a Roland MDX-650 milling machine. Milling took approximately 10 hours, with at least an additional 2 hours of post-processing. This method is suitable for custom production but not optimal for larger quantities. Two hairstyles are illustrated in Figure 9.

Figure 9. *Model produced by CNC milling*

2.4. Laser cutting machine

Using laser cutting technology, multiple hair accessories can be produced relatively quickly. Flat components can be cut within minutes. This method was tested for the fox and snake hair ornaments as it can be seen in Figure 10.

The first step involved creating flat blanks required for production. This method avoids significant material waste, as the machine cuts the base shapes –multiple pieces from a single sheet– which can then be bent into the desired form. The advantages are speed and reduced material loss, making this method more suitable for mass production than CNC milling.

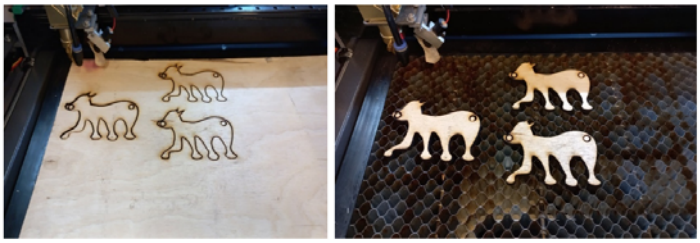

Figure 10. *Laser cutting process*

2.5. Steam bending

In this method, the material used is plywood made of glued veneer layers. Since both wood and adhesive become more pliable when exposed to heat and moisture, the cut pieces can be bent into shape using steam bending. The wood is placed in a well-insulated chamber into which hot steam is continuously introduced.

This method can also be tested at home, as was done in this research. Thinner elements are easier to bend; the material thickness used was 4 mm. Greater thickness can be achieved by gluing multiple bent layers together.

The type of wood is also important, as some species bend more easily. Ash, beech, and yew are more suitable than mahogany or teak. The method requires experimentation, as bent elements tend to straighten slightly after drying, while excessively tight curves may cause breakage (Forrester, 2021).

Initial laser-cut test pieces were produced, followed by home experimentation with steaming. The first attempt involved heating in water, which proved unsuccessful: the plywood delaminated as the adhesive failed, resulting in fragile pieces that broke during bending. The broken pieces are illustrated in Figure 11.

Figure 11. *Pieces soaked in water and fell apart*

In the second attempt, the cut shape was suspended above boiling water, exposed only to hot steam. Test bending was performed every 30 minutes, and after 2-3 hours of steaming, the piece became easily bendable. The steam bending process can be seen in Figure 12. The bending had to be done quickly while the material was still hot. A cylindrical object of appropriate diameter was used to shape the curve, secured with rubber bands and string. Based on literature recommendations, the piece was left fixed for 12 hours. After removing the fixation, the bent element was completed.

Figure 12. *Steam bending process*

The technology proved workable but requires refinement. Steam bending should be performed over a larger container to ensure sufficient steam exposure. A limitation was that bending could not be applied evenly to the entire ornament; for example, the legs could not be fully curved. Therefore, a press mould should be developed to bend and fix the entire piece uniformly. In industrial settings, bent wooden elements are always produced using robust press moulds.
The second snake pattern cut by the laser cutter fell apart upon removal from the sheet, indicating that its design requires modification. The design is illustrated in Figure 13.

Figure 13. *Disintegrated snake form*

The laser-cut pieces proved to be excellent test samples and revealed additional functions during testing. In the fox design, four functions are combined in a single product: aesthetic hair ornament, standalone hairpin, massage comb, and wide-tooth comb. The fox design can be seen in Figure 14.

Figure 14. *Fox hair ornament produced by steam bending*

The snake design also offers four functions, though slightly different: it can be used as a hair ornament, bracelet, and hairband. This additional function became apparent only after bending and testing with hairstyles, which can be seen in Figure 15.

Figure 15. *Snake hair ornament produced by steam bending*

The CAD models of the twin ravens were completed, but their physical realization had not been achieved by the time of submission. The two wooden production methods were tested on the fox and snake ornaments.

2.6. Press mould

During steam bending, the possibility of using a press mould emerged, which would simplify and speed up the bending process. More precise bending could be achieved with the required curvature. The model of the press mould can be seen in Figure 16. The press mould consists of multiple components. The lower part provides the curvature for bending, while the upper part mirrors this curvature. A 4 mm gap between the two parts accommodates the laser-cut pieces. Once the preform is placed

between the moulds, it can be fixed in the bent shape using four bolts and wing nuts. Wing nuts allow for quick fastening. Once the adhesive sets after steaming, the hair ornament is ready for use.

Figure 16. *Press mould*

This solution enables precise curvature, accelerates the steam bending process, and ensures that all parts of the ornament can be shaped correctly without time-consuming fixation.

3. SUMMARY, RESULTS

During the research, wooden multifunctional hair ornaments inspired by Japanese, ancient Egyptian, and Viking animal motifs were designed. Ergonomic and functional testing of prototypes based on freehand sketches and CAD models was carried out using 3D-printed mock-ups.
Manufacturing experiments showed that laser cutting followed by steam bending is a more efficient solution than CNC milling, particularly for series production. The prototypes confirmed multifunctional usability and demonstrated that culturally inspired wooden hair ornaments represent a viable aesthetic, functional, and sustainable product concept.

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