Employing Aluminum Foil As An Approach for Innovation in Shaping on Mannequin In Light of Sustainability

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Abstract:

The contemporary world is witnessing an increasing interest in environmental and sustainability issues, which has led to the development of new concepts in the fields of art and design, particularly fashion design. Hence, reconsidering the nature of the materials used and ways to employ them, to achieve innovation and reduce the negative environmental impact.

In light of the global trend towards sustainable design and the quest to reduce waste of resources, the employment of unconventional raw materials has become a fertile field for creativity and innovation. Humans seek to interact with the surrounding environment to attempt new experiences in a way that contributes to the development of new potentials and the ability to meet emerging needs.

The creative process usually focuses on the nature of the material, and we find that the more the designer knows about the material, the greater the integration of the artwork during implementation.

Aluminum foil is one of the simple materials with high potential, as it is lightweight, flexible, and able to retain shape, as well as its distinctive metallic luster. All these features make it an ideal material for design experiments on mannequins and add innovative aesthetic effects that reflect sustainable thought in the design process.

The research followed the descriptive experimental approach by identifying the properties of aluminum foil and experimenting with it on (satin and tulle) materials to change the surface features of these materials and obtain a new surface appearance using different methods, with application on mannequins to obtain innovative designs. The research concluded that aluminum can be used to create a range of clothing designs in light of the concept of sustainability.

Keywords:

Aluminum Foil – Shaping on Mannequin – Sustainability

Introduction:

The raw material is the first motivation for innovation. It provides an opportunity for creativity and design. Raw material includes everything that can be used by the designer to obtain tangible work and an aesthetic vision. Shaping on the mannequin is one of the best techniques to achieve creative designs. It motivates the artist to research, experimentation, and reasoning, which leads to unconventional solutions and new techniques that enrich the handling of various raw

materials to obtain designs that carry artistic expressions that fulfill the creative standards in the field of fashion design (Iman Osama et al., 2022-166).

The material is the basis of the artwork because of its artistic values. Each material has its own features and nature, and the artist often has special preferences for the materials. When artists recognize the material value and potential, they seriously search for different usages, through which they present new solutions that include novel ideas (Ayman Maher-2023-7).

The reformulation of raw materials has become a trend in the field of design. The designer no longer adopts a ready-made reality. There are different techniques that the designer can use to make innovative designs, in which the designer reshapes the surface of the material (Wafa Al-Qurashi et al., 2024-284).

Sustainable development has attracted much interest globally in its economic, social, and environmental fields. In a competitive and diversified economy that is based on building creative capabilities, stimulating innovation, and promoting environmental sustainability, the designer has a great opportunity to use a huge number of unconventional materials and new and interesting materials for artistic expression, which helps the designer to break free from the restrictions imposed by traditional materials (M. A. Nasef, 2024 - 1003).

The designer can reshape the surface and texture of the materials to obtain an innovative design by adding different effects such as (thermal fixation, pleats such as goffers and ruffles, embroidery in its various forms, the addition of multiple ribbons, printing with its different techniques, etc.) These techniques add to the material a different texture and appearance and transform the material from a two-dimensional piece into a three-dimensional piece (Wafa Al-Qurashi et al., 2024-284).

In this study, the surface appearance of the fabrics was changed and transformed into materials similar to high-cost embroidered fabrics, using aluminum foil, which is a simple but high-potential material. It is characterized by light weight, flexibility, and the ability to retain shape, as well as its distinctive metal luster, which makes it an ideal material to obtain aesthetic effects for the surface of the fabrics (satin and tulle) and to make evening dress designs through the technique of shaping on the mannequin, while adhering to the principles of sustainability.

Research Problem:

1. What is the possibility of employing aluminum foil in changing the surface appearance of fabrics in light of sustainability?
2. What is the possibility of making innovative designs on the mannequin using aluminum foil?
3. What is the possibility of achieving sustainability in clothing using aluminum foil?

Research Objectives:

1. Researching the properties of aluminum in terms of formability and integration with other materials.
2. Exploring the possibilities of aluminum foil as an artistic material in fashion design.
3. Employing aluminum foil to change the surface appearance of fabrics (satin and tulle).
4. Recognizing the views of specialized experts regarding the proposed designs.
5. Identifying the opinions of consumers about the proposed designs.

Research Significance:

1. Expanding the horizons of creativity using unconventional materials.
2. Keeping up with the global trend towards sustainable fashion.
3. Providing an applied experience that can be used in teaching design and experimentation on mannequins.
4. Raising the intellectual and applied aspects in the field of the clothing industry.
5. Paying attention to novelty in the methods and techniques used in the clothing industry.

Research Hypotheses:

1- There are statistically significant differences between the responses of the specialized experts regarding the proposed designs in terms of the suitability of the material for shaping on the mannequin.

2- There are statistically significant differences between the responses of the specialized experts regarding the proposed designs in terms of achieving the innovative, aesthetic, and economic aspects of employing aluminum foil in the design.
3- Aluminum foil can be used to change the surface appearance of fabrics and create innovative designs on the mannequin, according to the specialized experts.

Research Limitations:

Time Limits: The research was applied during the academic year 2025-2026.

Spatial Limits: Laboratories of the Clothing and Textile Department - Faculty of Home Economics - Al-Azhar University.

Technical Limits: The use of aluminum foil with (satin and tulle) materials in the design and implementation of women's clothing on the mannequin.

Research Methods:

- A questionnaire for the specialized experts regarding the raw materials.
- A questionnaire for the specialized experts regarding the implemented designs.

Research Methodologies:

The research follows the experimental descriptive approach by identifying the characteristics of aluminum foil and experimenting with it on (satin-tulle) materials to change the surface characteristics of these materials and obtain a new surface appearance in different ways, with the application to the mannequin to obtain innovative designs.

Research Recommendations:

1. Encouraging the designers and students to experiment with unconventional materials.
2. Including sustainability and environmental innovation topics within the academic curriculum of fashion design.
3. Organizing workshops and exhibitions that highlight the aesthetics of sustainable design using non-traditional materials.
4. Supporting research studies that link material innovation and environmental issues with contemporary design.

Research Terminology:

Aluminum Foil:

- Thin foil that is used to wrap food for safekeeping (Al-Maany Dictionary, Archived 24 October 2018).
- Aluminum Foil: It is aluminum prepared in the form of thin sheets, with a thickness of less than 0.2 ml, which may sometimes reach a thickness of 6 micrometers, used for packaging foods, these foil are flexible and can be easily wrapped around things, the foil is sometimes fragile, so it is reinforced with other materials such as plastic and plain paper to make it more useful. In the 20th century, aluminum foil replaced tin foil (Said, Olivier-2011).

Shaping on the Mannequin:

It is the adaptation and artistic shaping of the fabric on a suitable-sized mannequin or directly on the human body using a light cotton fabric (muslin) to prepare a properly shaped, controlled patron that takes the shape of the body smoothly while ensuring good mobility (Sue Jenkyn Jones, 2002, 118-123).

Sustainability

Defined by (Midhat Abu Al-Nasr, Yasmin Muhammad, 2017- 81) as an economic term that means developing the means of production in ways that do not lead to the depletion of natural and environmental resources to ensure the continuation of production for future generations, to meet the needs of the current generation without wasting the rights of future generations.

Literature Review:

The study of Shaimaa Mustafa (2022) on using environmentally friendly materials to achieve sustainability in the ready-made clothing industry. The study of Noha Ibrahim (2018) on creating green designs for functional clothing with a proposed marketing plan aimed to create

design solutions for clothing using environmentally friendly materials so that they can be used as suitable alternatives. The study of Wafaa Abdel-Radi Al-Qurashi et al. (2024) on using surface shaping techniques for non-traditional materials and shaping on a mannequin in designing evening dresses. The study of Eryuruk (2012), which analyzed the ready-made clothing manufacturing process to raise awareness and preserve the environment with the concept of green sustainability and found the problem in the production cycle from raw materials to the final product. The study of Shen, Bin (2014), which focused on sustainable design or green design or design with an environmental dimension, the researchers concluded that maintaining sustainability in the fashion industry is not complete unless design is the focus of the design process, as design affects the choice of materials, production and distribution processes, as well as affects consumer decisions.

Research Theoretical Framework:

The industrial applications of aluminum, known as the "future green metal", are increasing, and the amount of aluminum foil used in the production of the world is increasing. Aluminum foil ranked (256) among the most traded goods in the world in 2020, with a value of 12.4 billion US dollars, equivalent to 0.07% of the total world trade. Its importance stems from its distinctive position in the market and the increasing demand from consumers for it. It is one of the most used raw materials in our daily lives. It is also lightweight, but durable and attractive. Thanks to its silver gloss, aluminum foil is the ideal packaging material for almost any required commodity. Because of its distinctive insulating properties, it completely blocks light, moisture, oxygen, and other gases, in addition to bacteria and pathogens (Figure 1) (Ramil Hasanov, 2023, p. 479).

Figure 1. Aluminum Foil
https://vid.alarabiya.net/images/2021/07/09

Forming the Surface of the Material and Its Impact on the Design:

The formation of the surface of the material is one of the most important factors affecting the design process of fashion, as the material is not limited to its color or structural composition only, but its effect extends to its texture, softness, brightness, density, and mechanical properties. Together, these elements form the visual and functional identity of the costume and determine how the material interacts with light, movement, and the body.

The reconfiguration of the surface of the material or its artistic and technical treatment in an innovative way transfers the designer from the traditional to the bold and turns the clothing piece into a kind of art piece. Many modern techniques can be used to reconfigure the surface of the material and produce innovative fashion that achieves excellence in the world of fashion, such as (thermal fixation, embroidery, folds such as pleats and ruffles, addition such as ribbons in their multiple forms, printing with their various techniques, using ladder stitches and others) (Wafa Al-Qurashi et al., 2024-284).

In the current study, aluminum foil was used by adding it to the surface of the material in different ways to obtain innovative surface effects that increase the aesthetic value of the used fabrics and produce innovative designs.

Innovation and Sustainability:

Innovation and sustainability are key axes in the development of the modern fashion industry

as designers seek to find new design solutions that combine the aesthetic and creative aspect on the one hand and preserve the environment and reduce waste on the other. Sustainability is not only limited to the use of environmentally friendly materials, but also includes innovative thinking methods that aim to extend the life of the product, recycle materials, and reduce excessive consumption of resources (Gwilt, Alison-2014).

Through innovation in shaping on mannequin, the designer can create new artistic designs based on the use of discarded or unconventional materials such as aluminum foil, plastic, paper, or fabric residues, contributing to the concept of aesthetic and environmental sustainability at the same time (Porse, Moa, 2013, p. 29).

This combination of innovation and sustainability represents an advanced step towards responsible fashion design and keeps pace with scientific and technological development, reflecting the designers' awareness of their role in preserving the environment and promoting modern aesthetic values.

Sustainable design, or green design, is defined as the design whose multiple processes and aspects are related to the impact of the final product on the environment. Likewise, the US Department of Public Services defines sustainable design as the design that seeks to reduce the negative effects of a product on the environment and the health, and thus improves the performance of the product. Sustainable design mainly aims at reducing the consumption of non-renewable energy sources, reducing waste, and creating a healthier and more productive environment (Koehler, Karen-2013).

Sustainable development can also be seen as a consumer behavior that influences purchasing decisions. In addition to low cost, consumers expect products to protect the environment and ensure industrial sustainability and environmental balance. This is achieved by educating consumers about environmental problems within an integrated marketing perspective (H. Slama and others-2024-32).

The researchers believe that the employment of aluminum foil in fashion design as one of the modern trends in experimental art formation on the mannequin, falls within the concept of sustainability, through which simple raw materials have been converted into products of high aesthetic and functional value, as this unconventional material represents an innovative introduction to the production of new designs of a contemporary artistic nature, and at the same time achieves sustainability goals.

Research Empirical Framework:

Shaping fabric surfaces is one of the contemporary trends in the fields of design and fashion, as it contributes to the creation of new materials that carry distinctive aesthetic and functional features. In this context, the fabrics (satin and tulle) were handled using aluminum foil in various ways to apply aluminum on the surface of the material to create innovative surface effects that change the traditional feature of the material, and create a unique appearance that attracts attention and enhances the artistic value of the designs used in it.

Aluminum can be applied to the surface of the material through several techniques, including:

Topical Adhesive Technique: Adhesive is applied to specific areas of the fabric surface, and then aluminum foil is pressed onto it for varied surface effects or to add motifs in the form of dots, lines, or small areas.

Manual Gluing Technique (Collage): Shapes of aluminum foil are cut by hand and glued to the fabric to add surface texture and 3D appearance to the surface of the material.

Crinkle and Crease Technique: The aluminum foil is wrinkled and then fixed on the material for irregular surface effects; this technique shows various light reflections and gives the fabric an attractive visual movement that is especially suitable for tulle and satin to add a distinctive dynamic feature to the material.

Scraping Technique: After the aluminum is glued, parts of it are scraped or pressed with various tools to give a surface texture with varying light effects depending on density and direction, making the surface of the material richer.

Thermal Compression Technique: Depending on the fixation of aluminum foil on the fabric using the heat press with calculated temperatures, this method helps to transfer the metal shine

to specific places to obtain a homogeneous and stable surface and highlight the shiny effects clearly.

Recommended Care Methods for Maintaining Aluminum Foil-Treated Fabrics:

Proper care methods for clothing are important in preserving its aesthetic and functional value and increasing its life span, and thus reflect on economic value. Therefore, it is important to mention the recommended care methods to preserve fabrics treated with aluminum foil on their surface. The following table demonstrates these methods:

Table 1. **Methods of Care and Washing**

Care Method	Action Recommended	Rationale
Washing	Dry cleaning	Reduces mechanical friction and ensures the use of gentle cleaning materials that do not dissolve the adhesive.
Hand Wash	Flipping the dress over the back. Using cold water and a very light detergent	Washing in a washing machine or with hot water disassembles the adhesive and exfoliates the decoration.
Drying	Open-air drying, preferably maintaining the dress flat	The heat of the clothes dryers causes the adhesive to melt and distort the metal decoration.
Ironing	Avoid direct ironing on the decoration at all; ironing is done on the back of the fabric using medium heat and a separating cloth, which maintains the gloss of the decoration and prevents thermal damage.	Direct heat may damage the aluminum surface and dissolve the glue, causing it to adhere to the iron.
Warehousing	It should be stored flat or hung carefully.	Excessive folding results in cracking or peeling of the foil on the fold lines.

These precautions have also contributed to enhancing the **aesthetic value** of the materials by adding metal luster and innovative decorative additions. They have also helped raise the **economic value** of the fabrics by converting simple materials into high-quality materials characterized by a luxurious appearance at a relatively low cost. Thus, treating the fabrics with aluminum foil is an effective way to produce new materials that combine artistic creativity and economic feasibility.

The economic value lies in achieving the same lavish, glittering visual effect (which is similar to that produced by glossy glass crystal embroidery and silver threads), with enormous savings in raw material, production, and labor costs, supporting low-pricing strategies and increased production volume.

The Economic Value Can Be Determined At Several Points, Including:

1- Reducing Raw Material Costs: Aluminum foil is an inexpensive material and is available in very large quantities compared to piece- or carat-priced crystals, especially if it is high-quality crystals or from well-known brands**.**

2- Reducing Unit Cost: Aluminum can be purchased in the form of large sheets or rolls, which significantly reduces the unit cost compared to buying thousands of crystal beads.

3- Speed of Application on the Surface of the Material: Aluminum foil can be cut and formed using laser cutting or heat press/stamping machines, which are very fast processes and allow the production of huge quantities in a short time.

4- Technical Proficiency: This technique allows complex and large motifs to be applied in a single piece rather than installing thousands of grains individually.

5- Reducing Manual Labor: The installation of crystals in luxury designs requires skilled and expensive manual labor (hand embroidery) as opposed to aluminum, reducing reliance on specialized labor.

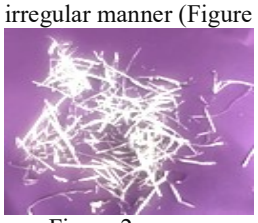
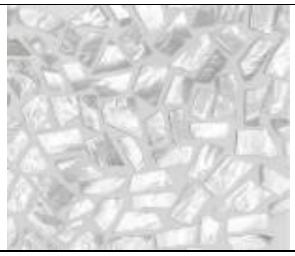
6- Easy Handling and Lightweight**:** Aluminum is a very lightweight material compared to glass crystals. This reduces shipping costs for finished products, which increases the profit margin.
7- Flexibility in Design**:** The elasticity of the aluminum allows it to be formed on flexible fabrics (such as satin) without adding weight or roughness that prevents the smoothness of the fabric.
8- Competitiveness in the Market: The use of aluminum makes it possible to produce luxury-looking copies at a low cost, enabling brands to put them on the fast-fashion markets or the middle price tiers, which are not able to afford the cost of crystals.

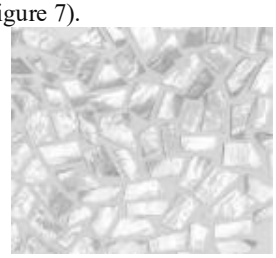
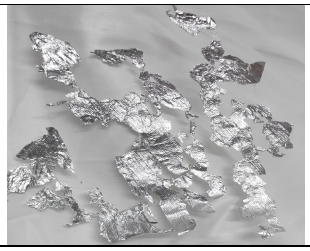
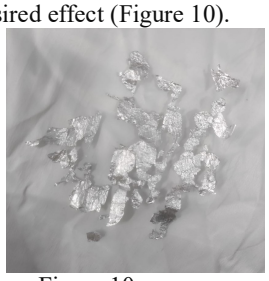
The Following is A Presentation of the Implementation Steps:

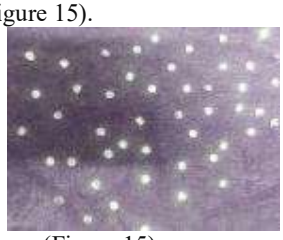
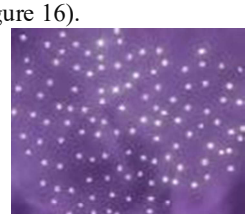
First: Executed Samples:

Five different methods were used to apply aluminum foil to the materials (tulle and satin) to change the surface of the material and make it richer and more distinctive. Five samples of these applications were carried out on the fabric to be presented to a group of specialized experts in the field of clothing and textiles to identify their views on these applications for aluminum foil on the mentioned materials. The following is an explanation of the steps and methods of implementing these samples:

Table 2. Innovative Samples and Their Implementation Steps

<table>
<tr><td colspan="3">Sample 1</td></tr>
<tr><td colspan="2">Materials Used: (Tulle and Satin) in purple.
Method of Application: Thermal application using two-sided adhesive vaseline strips to hold the layers together.</td><td>  </td></tr>
<tr><td colspan="3">Implementation steps</td></tr>
<tr><td>(1)
Aluminum foil was cut into thin strips in a random, irregular manner (Figure 2).
 
Figure 2</td><td>(2)
A layer of purple satin cloth, topped with a layer of double-sided vaseline strips, was spread, and then thin aluminum strips were distributed in parallel lines towards the groin as shown in Figure 3.
 
Figure 3</td><td>(3)
A layer of tulle of the same color as the satin was placed over the aluminum foil, and the iron was used to apply heat and pressure to the materials to fix the aluminum foil in the places where it was distributed, the paper was used as an insulator to facilitate the ironing process and the vaseline was not adhered to the iron (Figure 4).
 
Figure 4</td></tr>
<tr><td colspan="3">Sample 2</td></tr>
<tr><td colspan="2">Materials Used: White Tulle
Method of Application: Shapes of aluminum foil are cut by hand and glued to the fabric to add surface texture and 3D appearance to the surface of the material.</td><td>  </td></tr>
<tr><td colspan="3">Implementation steps</td></tr>
</table>

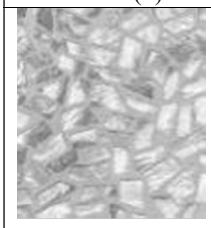
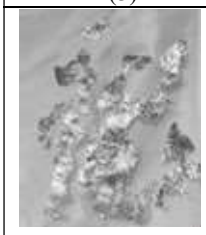
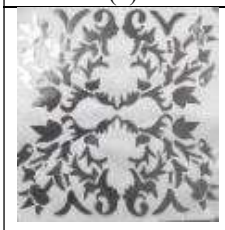
(1) Aluminum foil was cut into geometric shapes of different sizes (Figure 5).  Figure 5	(2) The aluminum foil was fixed to the white Tulle material in a mosaic style using adhesive, leaving simple spaces between the aluminum pieces (Figure 6).  Figure 6	(3) Another layer of the Tulle was fixed over the aluminum foil for the purpose of protection and was fixed from the letters using double-sided vaseline strips (Figure 7).  Figure 7
Sample 3		
Materials Used: White Tulle Method of Application: A Scraping technique was used after gluing aluminum foil by hand using an adhesive; parts of it are scraped to show varied effects and surface texture with varied light effects.		
Implementation steps		
(1) A cloth adhesive was placed on the surface of the Tulle material randomly (Figure 8).  Figure 8	(2) The aluminum foil was glued to the surface of the material, the Tulle (Figure 9).  Figure 9	(3) Parts of the aluminum foil were randomly scraped, and other parts were retained to obtain the desired effect (Figure 10).  Figure 10
Sample 4		
Materials Used: White Satin Method of Application: Laser cutting technique was used, in a specific design, then lining the material with a layer of aluminum foil to show the homogeneity between the glossy discharges and the material used, which enriches the surface of the material and distinguishes it		
Implementation steps		
(1) The satin material was cut with a laser cutting technique in the form of floral motifs (Figure 11)	(2) A layer of aluminum was placed underneath the satin material. (Figure 12)	(3) A layer of satin material was placed as a lining, then aluminum foil was placed on top, and then satin was separated and fixed between the layers with double-sided vaseline strips. (Figure 13)

<table>
<tr><td> 
(Figure 11)</td><td> 
(Figure 12)</td><td> 
(Figure 13)</td></tr>
<tr><td colspan="3">Sample 5</td></tr>
<tr><td colspan="2">Materials Used: (Tulle and Satin) in purple.
Method of Application: Shapes of aluminum foil are cut by hand and glued to the fabric to add surface texture and 3D appearance to the surface of the material.</td><td>  </td></tr>
<tr><td colspan="3">Implementation steps</td></tr>
<tr><td>(1)
Small circles of aluminum foil were cut using a paper punch (14).
 
(Figure 14)</td><td>(2)
A layer of satin cloth was placed, topped with a layer of double-sided vaseline strips, and then circles were distributed regularly on the surface of the material (Figure 15).
 
(Figure 15)</td><td>(3)
A layer of tulle of the same color as the satin was placed over the aluminum foil, and the iron was used to apply heat and pressure to the materials to fix the aluminum foil in the places where it was distributed, the paper was used as an insulator to facilitate the ironing process and the vaseline was not adhered to the iron (Figure 16).
 
(Figure 16)</td></tr>
</table>

Second: Suggested Designs:

Five innovative materials were produced using foil chips through the application of a number of surface formation techniques, to study their potential in enriching clothing design, and also exploring their aesthetic and plastic potential in the field of fashion design. After the completion of the preparation of these materials, some generative artificial intelligence systems were used to submit design proposals through shaping on mannequin. Four clothing designs were produced for each material separately. This procedure allowed comparing the employment of each material in different design solutions, and analyzing its suitability from an aesthetic and functional point of view. It also contributed to evaluating the ability of each material to achieve innovation and sustainability in fashion design. The following table shows these designs.

Table 3. Proposed Designs

Material (1)	1st design	2nd design	3rd design	4th design
				
Material (2)	5th design	6th design	7th design	8th design
				
Material (3)	9th design	10th design	11th design	12th design
				
Material (4)	13th design	14th design	15th design	16th design
				
Material (5)	17th design	18th design	19th design	20th design
				

Third: Implemented Designs:

The 1st Design:

Design Description: Long sleeveless evening dress, with a (mermaid) cut and a light tail, knitted on the body up to the thighs and then slightly widened to the end of the dress, the corsage consists of two layers; the first is a satin with a straight opening at the top of the chest and ends at the middle line, and the second layer of the tulle with a circular opening around the neck and ends at the middle line, decorated with aluminum foil on the right side of the design in the form of wrapped ribbons that form a flower on the side of the design with small aluminum circles distributed between the wrapped ribbons randomly. The skirt is a front croissant formed in the form of radiant drapes assembled on the left side of the design above the center line, the skirt finishes in a graded, rounded downward shape with aluminum circles distributed on the end of the skirt, forming a beautiful line that repeats circles distributed on the corsage.

Front Back

(Figure 17)

Material and Color: (Tulle and Satin) in dark emerald green.

Aesthetics of Applying Aluminum in Changing the Surface of the Material: The formation of aluminum foil in the ribbons wrapped on the corsage made it mimic the thick silver threads. The luster and shine of aluminum, which is similar to the shine of silver, clearly appear on the surface of the material. The use of aluminum with the dark green color in which the design is implemented has created a kind of contrast that attracts attention.

The small sparkling circles of irregularly distributed aluminum foil give the impression that they are small sparkling crystals distributed on the surface of the material. The aluminum foil is characterized by the ability to reflect light intensively, and when placed in the form of small points, it simulates the glittering effect given by the multiple faces of the crystal, creating a charming flash with every movement of the design. In addition, the use of this technology ensures the light weight of the decoration compared to the use of real glass crystal, which maintains the smoothness and softness of the material used.

The 2nd Design:

Design Description: Long sleeveless evening dress, neckline at the front (V) wraps around the neck, the bust was drained through ruffles top and bottom of the chest, around the middle area that extends from the bottom of the chest in an 8-shape to the bottom of the middle on the abdominal line area, covered with aluminum foil, the skirt is a wide drapes on the left side of the body that extends from the abdominal area high up towards the right side of the body to make beautiful soft folds that attract the eye to the bottom of the chest to hang the rest of the fabric in the form of longitudinal folds that move the eye down in a cool and thoughtful rhythm that increases the beauty and elegance of the design.

Front Back

(Figure 18)

Material and Color: (Satin) in light pink.

Aesthetics of Applying Aluminum in Changing the Surface of the Material: The material was decorated, and its surface was changed using a scraping technique after gluing the aluminum foil by hand using an adhesive. Parts of the aluminum foil are scraped to show the surface texture with various light effects. This was done in random places on the skirt, and the aluminum foil was repeated, through the use of aluminum foil on the surface of the material without scraping in the middle, in both front and back, to give a stylish and distinctive shape.

The use of aluminum in the design in the silver spaces randomly distributed on the surface of the material added an artistic and modern touch, avoiding the traditional organized embroidery, and it also gave an aesthetic effect to the material, making it emulate the Brocade fabric, which is characterized by prominent and glossy patterns of silk or metal thread woven inside it, which enhances the sense of depth and luxury in the design by simulating a luxurious fabric (brocade) using an innovative low-cost technology and this achieves an aesthetic and economic value for the design.

The 3rd Design:

Design Description: Asymmetric short evening dress without sleeves, the corsage in the front is asymmetrical. The right side is formed by oblique pleats. The left side is formed by a soft circular fold in the form of a flower. The bead is a straight skirt that takes the shape of the body up to the buttocks and then takes a straight shape to the end, where it reaches the knee. The material was decorated, and its surface was changed using aluminum foil with a thermal application technique using two-sided adhesive vaseline strips to hold the layers together. The aluminum foil is cut in the form of thin strips in an irregular, random way and glued adjacent to form parallel oblique strips. It was also distributed to the center line in the front to take a decorative shape that grades in density to end with thin decorative lines that reach the oblique pleats on the right side of the corsage in a stylish and distinctive shape, and from the right waist a long-streamlined tail hangs in the form of long, gradient length pleats that reach beyond the length of the dress. This tail balances the shortness of the dress and adds a luxury element to the design.

Material and Color: (Satin) in Dark Purple

Aesthetics of Applying Aluminum in Changing the Surface of the Material:

Front Back

(Figure 19)

Aluminum gives a strong metallic shine that surpasses many silver embroidery threads, and the distribution of aluminum scraps between two layers of satin and tulle made them simulate the lace material embroidered with silver threads, in addition to aluminum balls of different sizes distributed in the form of a belt around the middle line, which look like crystals scattered in a wonderful way that raised the aesthetic and economic value in the design, in addition to the light weight that is not comparable to the weight of the crystals, which achieves comfort in wearing and freedom in the movement and fall of the fabric.

The 4th Design:

Design Description: Mid-Length Asymmetric Evening Dress, the back is longer than the front, without sleeves, the chest cut is straight, the dress has a princess cut from the shoulder and a transverse cut on the middle line, and there is a reinforced decorative cut that starts from the middle line of the right front side through the left shoulder line to cover the left half of the arm and wraps to end at the middle line at the back, which is decorated with aluminum foil cut with the laser cutting technique.

The skirt is a cloche skirt that starts from the midline and ends in the front down the knee line, while its length extends to

the ankle at the back, laser hollow trims with aluminum foil are recited in the skirt in the shape of a wide line that increases the beauty and elegance of the design.

An ornamental design was prepared for vegetal motifs, and this design was cut on the satin fabric using a laser cutting machine to obtain the required satin material.
The material was prepared by fixing a layer of aluminum foil below the cuts in the satin and was fixed with double-sided adhesive vaseline strips using the iron, and another layer of satin was fixed under the aluminum foil to protect it from wrinkling or scratching and for easy wearing.

Front Back
(Figure 20)

Material and Color: (Satin) in Dark red
Aesthetics of Applying Aluminum in Changing the Surface of the Material: The cuts in the satin with the gloss of aluminum visible in the cutting places made the material look like a lace embroidered with silver threads, in addition to the color contrast between the dark red color that absorbs the light and the background in silver color that reflects the light, which gave a unique visual depth in the design, the reliance on laser cutting technique, and the inclusion of aluminum in it created a new surface appearance of the material that is difficult to achieve by traditional methods, which raises the artistic and aesthetic value of the design.

The 5th Design:
Design Description: Long sleeveless evening dress, fitted on the body up to the area of the thighs and then slightly expanded to the end of the dress, the chest cut at the front takes the shape of two triangles, the dress consists of two layers. The bottom layer is made of satin material, and the top is made of tulle material that is decorated with aluminum foil, where asymmetric shapes of aluminum foil were cut and fixed in the tulle material to start from the chest and extend diagonally to reach the knee line to the front side, and they are echoed in the same style at the back, which Increases the beauty and elegance of the design.

Front Back
(Figure 21)

The surface of the material was prepared by applying aluminum foil using a manual cutting and gluing technique, where shapes of aluminum foil are cut manually and glued to the fabric using a special adhesive for the fabric, to add surface texture and three-dimensional appearance to the surface of the material.
Material and Color: (Tulle and Satin) in white
Aesthetics of Applying Aluminum in Changing the Surface of the Material: The use of aluminum foil as an alternative to sequin or crystal embroidery in this design is an artistic intelligence that combines the achievement of aesthetic and economic value. Aluminum gives a shiny metal luster that surpasses the gloss of many plastic stones used in embroidery. The hand distribution of aluminum foil scraps in this organization created a unique visual fabric that mimics the effect of engineering mosaics. Despite the intensity of the decoration, the lightweight aluminum makes the design comfortable to wear and provides ease of movement, which enhances the aesthetic and artistic value of the design. On the other hand, the alternative use of aluminum foil instead of crystals and silver metal threads contributed to raising the economic value of the design significantly, in addition to saving the time and effort required to implement traditional hand embroidery.

Statistical Analyses

First: Executed Materials:

A questionnaire was conducted that was used as a measure to take the opinions of specialized experts regarding the executed materials, for which the surface shape was changed in 5 different ways, and the results were calculated using the weighted average, the weighted average percentage, and the standard deviation.

Opinions of Specialized Experts: n = 15

Table 4. The Weighted Average, The Weighted Average Percentage and Standard Deviation of Specialized Experts' Opinions Regarding the Executed Materials

Statements	Indicator Levels			Total Weights	Arithmetic Mean	Standard Deviation	Weighted Average Percentage	Level of material suitability
	% Agree	Neutral	%Disagree					
Aluminum foil is aesthetically suitable for changing the surface of fabrics.	66.7%	33.3%	-	40	2.67	0.47	89%	Suitable
Aluminum foil adds an attractive and distinctive texture to the fabric surface.	86.7%	13.3%	-	43	2.87	0.34	95.7%	Suitable
The use of aluminum foil makes the design more innovative and unique.	73.3%	20%	6.7%	40	2.67	0.60	89%	Suitable
Aluminum foil is an easy-to-form material on the fabric surface.	80%	20%	-	42	2.8	0.40	93.3%	Suitable
The weight of the aluminum foil is appropriate and does not burden the fabric.	60%	33.3%	6.7%	38	2.53	0.62	84 3	Suitable
Aluminum foil has a good degree of stability when attached to fabric.	66.7%	33.3%	-	40	2.67	0.47	89%	Suitable
Aluminum foil withstands use without quick damage.	80%	13.3%	6.7%	14	2.73	0.57	91%	Suitable
The use of aluminum foil supports the concept of sustainability.	66.7%	33.3%	-	40	2.67	0.47	89%	Suitable
Total Evaluation	90%							Suitable

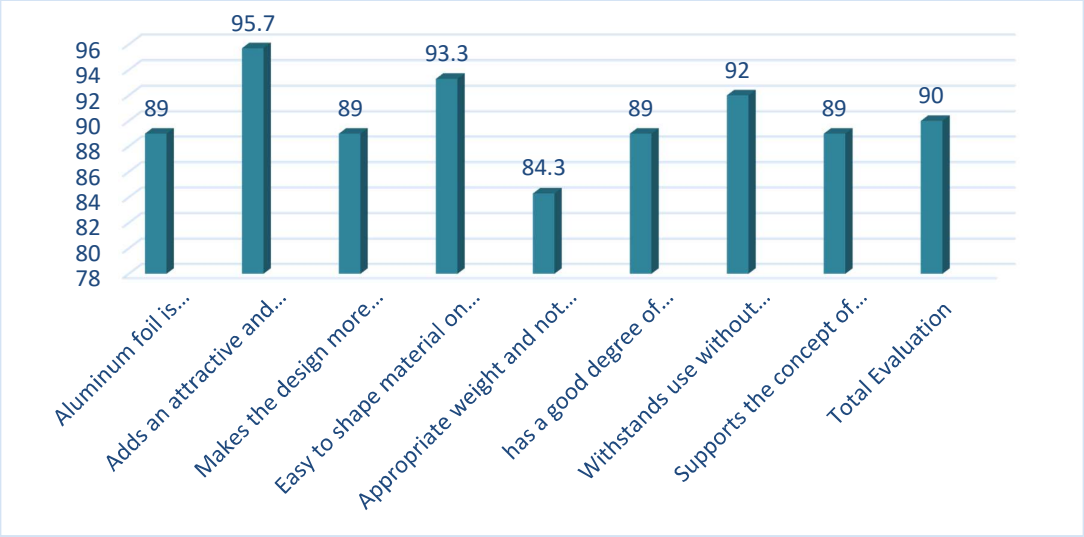


Figure 22. The Agreement of Specialized Experts According to The Quality Coefficients on the Suitability of the Implemented Materials

Table (4) and Figure (22) show:

• The agreement of the specialized experts regarding the suitability of the implemented material, and we find that the evaluation of the quality coefficients of the material is high, as it was found that all the statements obtained a quality coefficient at the level of (appropriate) based on the triple gradient of the weight

• The coefficients ranged between the statements as a whole by (90%) and are at an appropriate level, which shows the possibility of using aluminum foil in changing the surface of the fabrics based on the opinions of specialized experts.

Second: Proposed Designs:

First: Validity of the questionnaire:

1. Apparent Validity (Validity of Arbitrators):

The questionnaire was presented in its initial form to 10 specialized experts to express their views regarding the extent to which each of the questionnaire statements belonged to the dimension within which it was included or not, the validity of the statements to measure what they were developed for, and whether the questionnaire covers all dimensions of benefiting from aluminum foil as an approach for innovation in designing on the mannequin in light of sustainability, the clarity and accuracy of the statements, and their ease of understanding. In light of the agreement of the experts, which amounted to (80% or more), some statements were rephrased, and some amendments were made to them based on their comments.

2. Structural Validity (Internal Homogeneity):

The internal consistency was calculated using Pearson's correlation coefficient by extracting the correlation coefficient of each statement with the total score of the questionnaire, and the correlation coefficient of each item with the degree of the axis to which it belongs.

Table 5. The Correlation Coefficients Among the Degrees of Each Statement (With the Total Score of the Relevant Axis, and the Score of the Questionnaire As A Whole)

Statement	Correlation coefficient between the statement and the total score of the questionnaire	Correlation coefficient between the statement and the total score of the axis	Statement	Correlation coefficient between the statement and the total score of the questionnaire	Correlation coefficient between the statement and the total score of the axis
1	0,822**	0,890**	10	0,856**	0,742**

Statement	Correlation coefficient between the statement and the total score of the questionnaire	Correlation coefficient between the statement and the total score of the axis	Statement	Correlation coefficient between the statement and the total score of the questionnaire	Correlation coefficient between the statement and the total score of the axis
2	0,773**	0,820**	11	0,768**	0,754**
3	0,823**	0,755**	12	0,810**	0,839**
4	0,726**	0,798**	13	0,738**	0,752**
5	0,853**	0,804**	14	0,821**	0,763**
6	0,837**	0,828**	15	0,809**	0,739**
7	0,719**	0,878**	16	0,771**	0,824**
8	0,726**	0,767**	17	0,816**	0,861**
9	0,832**	0,804**	18	0,704**	0,748**

** statistically significant at (0.01) * statistically significant at (0.05)

The above table shows the following:

- The items of the questionnaire have a statistically significant correlation with the total score of the questionnaire, as the correlation coefficients ranged between (0.719**) and (0,856**), all of which are significant at the level of significance (0.01). Therefore, the questionnaire has a high degree of internal consistency of its statements, and the questionnaire measures what it was developed for.
- The items of the questionnaire have a statistically significant correlation with the degree of the axis to which they belong, as the correlation coefficients range between (0.739**) and (0.890**), and all of them are significant at the level of significance (0.01). Therefore, the statements of the questionnaire are coherent, and each statement belongs to the axis that includes it, which indicates the internal homogeneity of the questionnaire, and the questionnaire measures what it was developed for.

To ensure the stability of the questionnaire, the Cronbach's Alpha equation was calculated. The results were as shown in the following tables:

Table 6. Cronbach's Alpha Stability Coefficient

The Axes	Reliability Coefficient	Significance Level
The suitability of the material for the design of the mannequin	0,883	significant
Innovation in Design Using Material	0,924	significant
The aesthetic aspect	0,825	significant
The economic aspect	0,941	significant
Questionnaire Total Score	0.898	significant

The previous table shows the reliability coefficients for each dimension of the questionnaire, which ranged between (0,825: 0,941), while the value of Cronbach's alpha coefficient for the questionnaire as a whole was 0.898, and these values indicate that the questionnaire has an appropriate degree of reliability to measure the validity and quality of the designs, and thus the reliability of the questionnaire as a whole.

Formulation of the questionnaire in its final form:

The questionnaire was finalized and consists of four dimensions, the first dimension: The suitability of the material for the design on the mannequin (consists of 4 statements), the second dimension: Innovation in design using the material (consists of 4 statements), the third dimension the aesthetic aspect (consists of 4 statements), the fourth dimension the economic

aspect (consists of 5 statements).

Statistical parameters used in data analysis:

The data was analyzed, and statistical coefficients were calculated using SPSS Software. The following are some of the statistical methods used:

1. Pearson Correlation Coefficient
2. Cronbach's Alpha Coefficient
3. Weighted Average and Weighted Average Percentage
   The weight of the answers to each statement is as follows:
   1.00 – 1.67 (Not suitable)
   1.68 – 2.35 (Somewhat suitable)
   2.36 – 3.00 (Suitable)
4. Standard Deviation
5. One-Way ANOVA Test

This part includes the results of the applied study with the aim of employing aluminum foil as an approach for innovation in shaping on mannequin in light of sustainability.

Table 7. The Weighted Average, Weighted Average Percentage, Standard Deviation, and Ranks of Designs According to the Responses of the Experts to All Dimensions (n = 15)

Designs	Indicator Levels			Total Weights	Weighted Average	Weighted Average Percentage (Quality Coefficient)	Ranks of Designs	Design Level
	Suitable	Somewhat Suitable	Unsuitable					
1	186	52	32	694	2.57	85.7 %	9th	Suitable
2	170	60	40	670	2.48	82.7 %	11th	Suitable
3	270	0	0	810	3.00	100.0 %	1st	Suitable
4	136	73	61	615	2.28	75.9 %	16th	Somewhat Suitable
5	128	72	70	598	2.21	73.8%	18th	Somewhat Suitable
6	179	56	35	684	2.53	84.4%	10th	Suitable
7	256	13	1	795	2.94	98.1%	2nd	Suitable
8	143	69	58	625	2.31	77.2%	15th	Somewhat Suitable
9	251	18	1	790	2.93	97.5%	3rd	Suitable
10	195	46	29	706	2.61	87.2%	8th	Suitable
11	156	65	49	647	2.40	79.9%	13th	Suitable
12	211	39	20	731	2.71	90.2%	6th	Suitable
13	121	72	77	584	2.16	72.1%	19th	Somewhat Suitable
14	231	26	13	758	2.81	93.6%	4th	Suitable
15	163	63	44	659	2.44	81.4%	12th	Suitable
16	151	66	53	638	2.36	78.8%	14th	Suitable
17	204	42	24	720	2.67	88.9%	7th	Suitable
18	116	72	82	574	2.13	70.9%	20th	Somewhat Suitable
19	220	34	16	744	2.76	91.9%	5th	Suitable
20	132	72	66	606	2.24	74.8%	17th	Somewhat Suitable

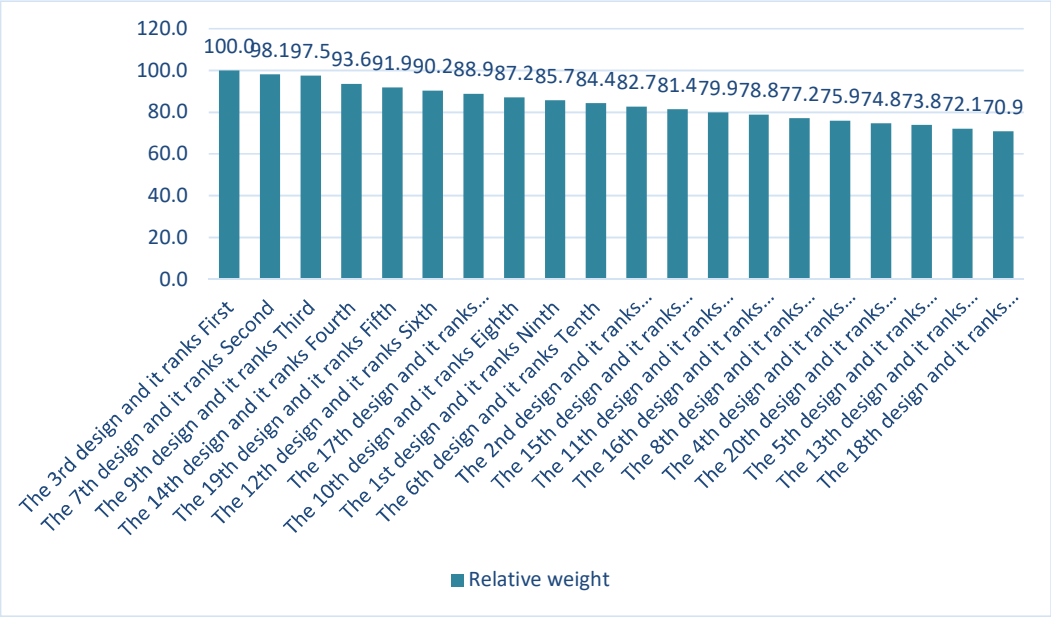


Figure 23. The Ranks and Levels of Designs According to The Experts' Responses To All Dimensions

Table (7) and Figure (23) show:

The ranking of the proposed designs according to the specialized experts' responses to all dimensions is as follows: Design (3) achieved a suitable level with a weighted average of (3), and a percentage of (100%), ranking first; followed by Design (7) with a suitable level with a weighted average of (2.94), and a percentage of (98.1%), ranking second; followed by Design (9) with a suitable level with a weighted average of (2.93), and a percentage of (97.5%), ranking third; followed by Design (14) with a suitable level with a weighted average of (2.81), and a percentage of (93.6%), ranking fourth; followed by Design (19) with a suitable level with a weighted average of (2.76), and a percentage of (91.9%), ranking fifth; followed by Design (12) with a suitable level with a weighted average of (2.71), and a percentage of (90.2%), ranking sixth; followed by Design (17) with a suitable level with a weighted average of (2.67), and a percentage of (88.9%), ranking seventh; followed by Design (10) Design (1) achieved a suitable level with a weighted average of (2.61), and a percentage of (87.2%), ranking eighth. Design (1) followed with a suitable level, a weighted average of (2.57), and a percentage of (85.7%), ranking ninth.

Design (6) followed with a suitable level, a weighted average of (2.53), a percentage of (84.4%), ranking tenth. Design (2) followed with a suitable level, a weighted average of (2.48), and a percentage of (82.7%), ranking eleventh. Design (15) followed with a suitable level, a weighted average of (2.44), a percentage of (81.7%), ranking twelfth. Design (11) followed with a suitable level, a weighted average of (2.40), a percentage of (79.9%), ranking thirteenth. Design (16) followed with a suitable level, a weighted average of (2.36), a percentage of (78.8%), ranking fourteenth. Design (8) followed with a suitable level, a weighted average of (2.31), a percentage of (77.2%) and ranked fifteenth, followed by design (4) which achieved a suitable level with a weighted average of (2.28), a percentage of (75.9%) and ranked sixteenth, followed by design (20) which achieved a suitable level with a weighted average of (2.24), a percentage of (74.8%) and ranked seventeenth, followed by design (5) which achieved a suitable level with a weighted average of (2.21), a percentage of (73.8%), and ranked eighteenth, followed by design (13) which achieved a suitable level with a weighted average of (2.16), a percentage of (72.1%), and ranked nineteenth, followed by design (18) which achieved a suitable level with a weighted average of (2.13), a percentage of (70.9%), and ranked twentieth.

Thus, the best designs proposed according to the agreement of the specialized experts are the designs (3, 7, 9, 14, 19, 12, 17, 10, 1, 6, 2, 15, 11, 16), where they obtained a suitable level in ratios ranging from (100% to 78.8%), and the designs (8, 4, 20, 5, 13, 18), where they obtained a somewhat suitable level in ratios ranging from (77.2% to 70.9%).

Table 8. Variance Analysis to Study the Significance of Differences Among the Specialized Experts' Responses to the Proposed Designs for Each Axis of the Questionnaire

Axes of the questionnaire:	Source of variance	Degrees of freedom	Sum of Squares	Mean of Squares	F	Significance	Significance level
The suitability of the material for the design on the mannequin	among designs	19	612.14	32.21	16.62	0.000	**Significant at 0.01.
	Inside Designs	280	542.80	1.93			
	Total	299	1154.94	-			
Innovation in Design Using this Material	among designs	19	294.21	15.48	8.48	0.002	Not significant at (0.01)
	Inside Designs	280	488.13	1.73			
	Total	299	782.34	-			
The aesthetic aspect	among designs	19	284.45	14.97	6.47	0.006	Significant at (0.01)
	Inside Designs	280	646.16	2.31			
	Total	299	930.58	-			
The economic aspect	among designs	19	556.83	29.16	12.68	0.000	Significant at (0.01)
	Inside Designs	280	635.42	2.31			
	Total	299	1203.32	-			

Table (8) shows:

- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the suitability of the material for the design on the mannequin, where the value (F) reached 16.62 and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in the suitability of the material for the design on the mannequin.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the designs proposed in the design innovation using the material, where the value of (F) reached 8.48 and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in using the material for the design.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the aesthetic aspect, where the value of (F) is 6.47 and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs in innovation, in the aesthetic aspect.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the economic aspect, where the value of (Q) reached 12.68, and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in the economic aspect.

Table 9. Variance Analysis to Study the Significance of Differences Among the Specialized Experts' Responses to the Proposed Designs for the Questionnaire As A Whole

the questionnaire as a whole	Source of variance	Degrees of freedom	Sum of Squares	Mean of Squares	F	Significance	Significance level

"Employing Aluminum Foil As An Approach for Innovation in Shaping on Mannequin In Light of Sustainability"	among designs	19	6711.65	353.24	48.35	0.000	Significant at (0.05)
	Inside Designs	280	2045.32	7.30			
	Total	299	8756.93				

Table (9) shows:

- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the extent to which aluminum foil can be used as an approach for innovation in shaping on the mannequin in light of sustainability, where the value (F) reached 48.35 and the level of significance is less than the level of significance (0.05), which indicates that there are differences between the designs, in the questionnaire as a whole.

Interpreting the results associated with testing the validity of the study hypotheses:

1. Findings related to the first hypothesis of the study:

"There are statistically significant differences between the specialized experts' responses to the proposed designs in the following aspects (suitability of the material for the design on the mannequin, innovation in the design using the material, aesthetic aspect, economic aspect).

The results proved that:

- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the suitability of the material for the design on the mannequin, where the value of (F) reached 16.61, and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in the suitability of the material for the design on the mannequin.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the designs proposed in the design innovation using the material, where the value of (F) reached 8.48, and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in using the material for the design.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the aesthetic aspect, where the value of (F) reached 6.47, and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in innovation, in the aesthetic aspect.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the economic aspect, where the value of (F) reached 12.68, and the level of significance is less than the level of significance (0.01), which indicates that there are differences between the designs, in the economic aspect.
- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the extent to which aluminum foil can be used as an approach for innovation in shaping on the mannequin in light of sustainability, where the value of (F) reached 48.35, and the level of significance is less than the level of significance (0.05), which indicates that there are differences between the designs, in the questionnaire as a whole.

2. Findings related to the second hypothesis of the study:

- There are statistically significant differences at the level of significance (0.01) between the specialized experts' responses to the proposed designs in the extent to which aluminum foil can be used as an approach for innovation in shaping on the mannequin in light of sustainability, where the value of (F) reached 48.35, and the level of significance is less than the level of significance (0.05), which indicates that there are differences between the designs, in the questionnaire as a whole.

3. Findings related to the third study hypothesis:
"Aluminum foil can be employed as an approach for innovation in shaping on the mannequin in light of sustainability from the specialized experts' point of view."
The results proved that:
Aluminum foil can be used as an approach for innovation in shaping on the mannequin in light of sustainability from the point of view of the specialized experts. The best designs proposed according to the agreement of the specialized experts are (3, 7, 9, 14, 19, 12, 17, 10, 1, 6, 2, 15, 11, 16), where they obtained a suitable level in ratios ranging from (100% to 78.8%), and the designs (8, 4, 20, 5, 13, 18), where they obtained a somewhat suitable level in ratios ranging from (77.2% to 70.9%).

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