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Reverse Engineering as a Contemporary Perspective for Producing Contemporary Ceramic Models Inspired by Saudi Heritage

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ABSTRACT: Reverse engineering involves identifying a set of specifications for a product or design originally created by the designer and dismantling it by analysing its components. It follows a series of steps to extract methods for classifying these components, making it a useful approach for solving problems related to assembling, mixing, or producing the reverse-engineered product. While many studies have explored the applications of reverse engineering in developing or reproducing industrial products, its use in the arts, particularly ceramics, remains largely unexplored. This study addresses this gap by posing the following question: Can reverse engineering, as a contemporary approach, produce ceramic models inspired by Saudi heritage? The study aims to test the hypothesis that the reverse engineering mechanism can be applied to create contemporary ceramic models inspired by Saudi heritage. The study found that reverse engineering can generate new shapes from a single reference, living or non-living, for use in contemporary ceramic designs. It was also found that the Saudi heritage possesses qualities well-suited for reverse engineering applications.

KEYWORDS: Reverse Engineering, Contemporary Ceramics, Saudi Heritage.

1 INTRODUCTION

The scientific and technological advancements of the 20th century brought a revolution that transformed classical approaches in the arts. Once seen as separate from intellectual and philosophical movements, ceramic art began to absorb these influences. Technological developments introduced new values and aesthetics, offering artists greater freedom of expression and innovation in shaping their works. As a result, ceramics evolved beyond mere form or technique, taking on expressive values that reflected the artist's inner ideas, often developed through multiple stages of experimentation. This shift allowed ceramic artists to align their work with the modern era, utilizing various techniques and harnessing science and technology to express their ideas, leading to new conceptual and intellectual forms.

Technology, as an integral part of artistic creation, went beyond being a tool for constructing or treating surfaces. Through experimentation with different techniques, boundaries between material, form, and expression in the arts blurred, leading to a merging of artistic disciplines. Ceramic artists no longer relied solely on traditional materials and methods but sought to innovate, breaking free from old constraints. This led to a diversity in form, content, techniques, and presentation, infusing ceramic art with a new spirit. It shed its utilitarian function, adopting a fresh aesthetic that fused traditional ceramic elements with modern art philosophies, creating a distinct form of modern ceramics.

The Industrial Revolution defined modernity, while postmodernity ushered in globalization and the rise of information and technology. With its unique physical and chemical properties, ceramic art found applications in numerous fields, from electrical and nuclear products to optical and magnetic technologies.

In this context, the contemporary artist is seen as a key innovator, adapting scientific and technological advancements to communicate ideas and goals through artistic works. By embracing modern scientific concepts and theories, ceramic artists explore how their medium can best serve the contemporary age (Abubakr, 1978, p. 37).

One such concept is reverse engineering, which has emerged due to rapid technological advancements. These technologies have not only changed the way art is created but have also revealed new resources that impact execution. As a result, reverse engineering has become essential for the evolution and continuity of creative works in a new form.

Based on the above, the problem of the study revolves around the following question:

Can reverse engineering, as a contemporary perspective, produce contemporary ceramic sculptures inspired by Saudi heritage?

1.1 Research Objectives

The research aims to employ reverse engineering mechanisms to produce contemporary ceramic sculptures, identify the steps and stages of reverse engineering and the difference between it and direct design, and link reverse engineering to the arts by studying reverse engineering concepts and applying them in the design of ceramic works.

1.2 Research Hypotheses

The application of reverse engineering mechanisms can be utilised in creating contemporary ceramic sculptures.

1.3 Research Significance

- Understanding the key concepts related to reverse engineering processes from functional and aesthetic perspectives.
- Highlighting the importance of utilising the perspective of reverse engineering in producing ceramic sculptures.
- Studying and reshaping the optimal sequence of reverse engineering processes for ceramic products.
- Studying Saudi heritage from a contemporary perspective through reverse engineering.

1.4 Research Method

The research applies a descriptive-analytical methodology. The concept of reverse engineering, its mechanisms and rationale, the general processes and stages involved, its importance in ceramic production, and the potential of Saudi heritage to inspire these models have been fully described and analyzed.

2 Theoretical Framework

2.1 The Emergence And Concept Of Reverse Engineering

Reverse engineering applications have spread and diversified widely, attributed to significant technological advancements. It has been applied throughout different economic activities across various eras, especially in industrial and military fields. Many countries initially banned its use in the early 1970s due to concerns regarding intellectual property rights or viewing it as an unconventional approach different from traditional production methodologies, not recognizing it as a thought or educational method for seeking new and improved opportunities and innovations.

The concept of reverse engineering varies depending on the field of theory applied. It is a set of sequential practices that work towards understanding a specific system or product, serving as one of the most efficient means for development processes as it integrates design and knowledge of the base product with ideas and experiences of the reverse engineering user (Alafandi, 2014). It is an approach to reverse conventional engineering processes by analyzing the intensive knowledge contained within the product intended for reverse engineering operations, involving identifying steps, elements, and methods used during the manufacturing process (Abdulqader, 2014). This includes rediscovering the technical principles of structural analysis, technological analysis, performance and function analysis, and operational analysis, thereby reframing design data for a system or product to design new parts for the system to enhance performance (Ibrahim, 2006).

Thus, reverse engineering involves identifying the specifications of a product or design created by its designers and breaking it down by analyzing its components. It follows a series of steps to extract methods for classifying these components. Hauke (1999, p. 54) describes it as "reverse" because its operations follow the opposite sequence of the typical design process. (Al-Afandy, 2014).

Forsberg (2004) describes it as "a method used to address an unauthorized problem regarding the assembly, blending, production, or activities related to building a product intended for reverse engineering". Therefore, reverse engineering must address essential elements, which include:

Product: A type of finished item that currently exists.

Data: Information that, when combined, forms the basic analysis process.

Component: The target element in the formation process, consisting of replaceable or renewable parts.

Work or performance: The process of identifying what achieves the desired goal.

Comparative analysis: The process of comparing two or more elements of a product or system that perform the same function. (Fathi, et al., 2022).

Reverse engineering is a comprehensive field that helps highlight any part or component’s physical and technological principles through disassembly and analysis of fundamental aspects related to structure, function, and operation. It signifies technology for renewal or innovation, leading to the replication of innovations in various products. When discussing reverse engineering, it is crucial to understand the distinction between it and forward engineering.

Engineering generally involves designing, manufacturing, assembling, and maintaining products and systems. There are two types of engineering: forward engineering and reverse engineering.

Forward engineering refers to the traditional process of starting with abstract or conceptual designs and progressing toward implementing systems or devices (Raja, 2007). It involves moving from high-level designs to functional, physical products (Elliot Schakowsky, 1990, p. 14). In contrast, reverse engineering analyses and understands an existing model to create a new, often higher-performing version of the original program or machine.

The existence of new products from an existing product does not mean that it is an imitation, so it is necessary to differentiate between reverse engineering and imitation:

Many people mistakenly equate reverse engineering with imitation. However, imitation involves replicating the original product’s features and functions, often with lower efficiency and less attention to production standards. In contrast, a product created through reverse engineering typically matches or exceeds the original regarding quality and integrated technology (Sunday, 2018, p. 469). Reverse engineering promotes innovation and development, as it involves analysing and understanding the existing design to create a new, improved version with higher technological capabilities. Schumpeter viewed innovation as the creative force behind technological change, describing it as the productive transformation of intangible assets, such as ideas (Kogabayev & Maziliauskas, 2017, p. 60).

There are two contradictory views on the relationship between reverse engineering and innovation. The first group believes that reverse engineering is against innovation since it is an intrusion on original products, and with reverse engineering, the incentive to innovate decreases because the values of innovations and intellectual property rights become unable to compensate for intellectual property fees (Kåresen, 2019, p. 23), while the second group believes that reverse engineering is a motive for innovation since it is only a stage of improvement innovation after disassembling, analysing, and understanding the original product.

Reverse engineering is found for various reasons and motivations for use, including:

Reducing product obsolescence: Many products may become obsolete, or it may be impossible to purchase an existing component. In this case, it may be possible to reverse engineer the product to create a replacement with currently available materials.

Maintaining the original product: Maintenance may be required, so reverse engineering is also required.

Cloning (creating copies): This is done using an original product that can be developed into a reverse-engineered product.

Educational purpose: Reverse engineering can be an educational tool that enables understanding of successful and unsuccessful designs (so that this knowledge can be built upon in the future).

Reducing costs: By understanding what goes into the product, cheaper alternatives can be obtained as replacement parts.

Redesign: Companies may reverse engineer their no longer useful products so that they can be improved and made useful again, either by reducing costs or increasing quality or both.

Harvesting materials or scrapping: The reverse engineer may need some parts of a product, which requires disassembling them to use them in another product or for uses different from the original. (Goodarzi, 2011, p. 349)

Sustainable and rapid economic growth: Supporting technological change and progress through reverse technology transfer is the best way to achieve sustainable and rapid economic growth if it is part of a broader strategy to develop productive capacities and expand productive employment opportunities.

Technology transfer through reverse engineering helps to collect technologies of varying levels and diversity in terms of development and from multiple sources (Sunday, 2018, p. 468)

Reverse engineering has been applied across various scientific fields, including redesigning software and tangible or intangible products (Khalili, 2022, p. 444).

Since reverse engineering, with its diverse fields, encompasses all aspects of life, it can be applied in all areas of art, especially in ceramics, which is the focus of the current study. This field leads artists to achieve renewed and contemporary results characterised by pure aesthetic and artistic concepts and relationships through necessities that arise for the artist, either for reconfiguration or to preserve the ceramic form.

2.2 Contemporary Arts And Their Relationship With The Use Of Reverse Engineering In Ceramics

The directions of postmodern art have diversified due to their interest in more than mere expression. Numerous social and political contradictions, in addition to the vast technological flow, have surrounded postmodern artists. As postmodern arts have abandoned self-referentiality, art has transcended its traditional scope and become an event that can be expressed through various technological means. The artist only needs to unleash their intellectual activity. This immense amount of technology, culture, and thought has led to the emergence of multiple trends, all interconnected in some way.

At the beginning of the twentieth century, rapid industrial and technological developments became intertwined with all aspects of human life, and artists' tools, ideas, and directions evolved. This evolution has added depth and significant visual, sensory, and intellectual value to artistic work. Artists have been influenced by various scientific and technical concepts and methods that have affected their artistic style and thinking.

When delving into postmodern art and the changes, developments, and theories that have produced artistic movements with different characteristics, we find that many artists in general, and ceramic artists in particular, have produced their artistic works with the concept of reverse engineering, albeit from a philosophical perspective carrying artistic, expressive, aesthetic, or technical values.

One of these movements is Cubist art, with one of its prominent trends being the reconstruction of shapes by simplifying details and elements into an architectural form. Cubism began as an intellectual revolution against the prevalent expressive artistic forms before the 1920s, with its beginnings marked by sharp variations that deeply impacted the artist's and the audience's ways of thinking.

Cubism is one of the movements that relied on looking at pieces, sculptures, and objects from multiple perspectives, contrary to traditional methods that rely on a fixed single viewpoint. Through this multidimensional perspective of the physical view, Cubists dismantled shapes into their original components, analysed them, and reassembled them in an abstract manner to create a final form with a different meaning than before.

From a technical standpoint, the changes led to the abandoning of many fundamental elements in artistic compositions and how they were understood and appreciated. To replace these elements in the artistic compositions and their appreciation and understanding by the public, the early Cubists resorted to inventing new analytical systems by dismantling three-dimensional shapes and reassembling them using intersecting formal levels, liberated from physical perspective and depth.

Among the most important and prominent Cubist artists is Pablo Picasso, who deviated from traditional form boundaries. Looking at Picasso's ceramics, which focused on this material and used it as a medium for painting, we find ceramics bearing new aesthetic values. In the beginning of his ceramic works, he decorated various dishes in different sizes with quick and simplified brush strokes, creating shapes of simple lines expressing natural or animalistic elements that occupied his mind. He also ventured into treating the flat oval and sculptural shapes by utilising prepared clay forms for drying and firing as an intermediary material. Inspired by pottery forms, he reshaped and decorated them, creating new forms with his delicate touches representing sculpted women in different poses, transforming them into vases and vessels, or turning them into birds or animalistic forms (Youssef Taha, 1989, p. 193) (Figures 1, 2, 3).

In Picasso's works, we find that Cubist art and the use of ceramic forms as expressive mediums, whether through painting on them or through processing ceramic forms in new formulations, represent nothing but an expressive, technical, and ideological direction in harmony with the modern era and the changes it presents. They allow us to re-engineer artistic forms, whether expressively, technically, or aesthetically (Taha, 1989, p. 15).

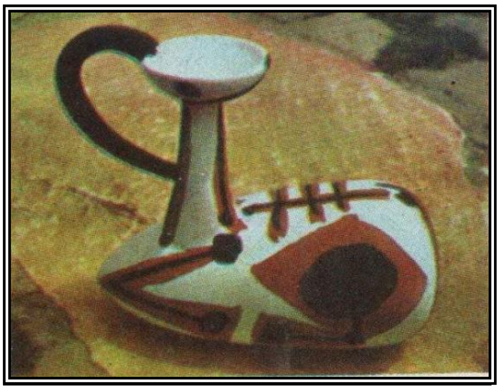

Fig. 1. Pablo Picasso, Shoe, 1950 (Hassan, 1974, p. 109)

Fig. 2. Pablo Picasso, Big Bird Black Face (https://www.veniceclayartists.com/picasso-ceramics)

Fig. 3. Pablo Picasso, Pair of Femme Pitchers (https://www.veniceclayartists.com/picasso-ceramics/)

The concept of restructuring artworks was not limited to Cubist art alone. However, other movements in the postmodern era emphasised this concept following the characteristics of that period. Pop Art had a significant influence on artistic works in general and ceramic works in particular, with artists of this movement executing forms that reflect this consumer society, expressing their ideas by depicting a part of this reality within their works. This was achieved by copying a portion of reality (Figure 4) or using ready-made forms and reshaping them within the artwork (Figure 5). Artists did not stop at this point but utilised various materials with different techniques to make ceramic works that realistically reflect society, sometimes combining multiple techniques in one work to enrich its content and link their ideas to the culture of society by restructuring those forms in line with the ideology of this movement.

Fig. 4. Porcelain Artwork by Elaine Levin (https://www.themarksproject.org/marks/shaw)

Fig. 5. Artwork by Paul A. Dresang, Year of Production: 2022, Location: Racine Art Museum (https://www.mutualart.com/Exhibition/Fool-the-Eye--Addressing-Illusion-in-Con/BDC4A2754F29E6A9)

Modern ceramic art took diverse expressive and intellectual directions, with artists blending the boundaries between different artistic fields and daily life. Assemblage artists used materials found in the environment in all its forms within their artistic works to give the artwork a more realistic reflection of society's nature and its various issues. Assemblage artists adopted the principle of continuous exploration and experimentation with different materials and techniques to imbue them with expressive values, where the materials used from the environment became the artwork.

Ceramic artists utilised ready-made ceramic forms, consumed them, and crafted them according to the content of the artwork and the artist's vision of shapes (Figure 6), achieving forms with modern expressive and intellectual values.

The postmodern era and the intellectual movements that emerged during this time feature artists who actively engaged with modern scientific and technological advancements. Their works reflect ideological, expressive, aesthetic, and utilitarian values, with reverse engineering playing a significant role in the creations of many artists (Youssef Taha, 1989).

Fig. 6. Artwork by P. Armand Fernandez, Year of Production: 1990
(http://www.artnet.com/artists/arman/as-in-the-sink-8aUczSjV9VIF-Nbn-vUr6g2)

Ceramic art is no longer isolated from intellectual and philosophical trends. Scientific and technological advancements have introduced new values and aesthetics that were previously absent. As a result, ceramic artists have developed directions that align with modernity, transforming their works from mere functional items to significant artistic expressions. Modern ceramic artists have begun experimenting with various materials and techniques, integrating technology to enhance their creations. The applications of ceramics in contemporary technology are numerous and extensive, particularly in fields that utilise their physical and chemical properties, such as electrical, nuclear, optical, and magnetic products.

Contemporary artists are among the leading researchers exploring new ideas and harnessing scientific and technological progress to convey their goals through artistic work. They seek innovative ways to reformulate traditional ceramic products, adapting them to the modern era using reverse engineering concepts (Taha Youssef, 1989).

The concept of modern re-engineering has evolved significantly. Rapid technological advancements and the introduction of diverse scientific technologies have caused many changes across various fields. Re-engineering has become essential for the success and continuity of many works, particularly in ceramics, which has shifted from a secondary utilitarian art to a primary aesthetic art, ultimately achieving a balance between aesthetic and utilitarian values.

Ceramic art reflects contemporary intellectual changes, prompting artists to develop new and unfamiliar creative depths. By employing reverse engineering, artists achieve their goals within the medium. They leverage technology and science to convey their ideas, creating fresh artistic and intellectual concepts. The reverse engineering method allows artists to communicate their visions innovatively, often altering ceramic pieces' primary functions while retaining their essential forms. This spontaneous freedom encourages diverse experimental approaches, driven by limitless imagination and raw materials, which fuels the creative energy of contemporary artists (Al-Hatimi, 2013, p. 45).

Integrating engineering principles, particularly reverse engineering, into artistic practice enables artists to reformulate, dismantle, and analyse their designs to create new works with utilitarian or aesthetic goals. This approach enriches the field of art, especially ceramics, by enhancing existing capabilities and introducing novel formulations.

When applying reverse engineering to artwork, it is crucial to understand its intended purpose and the appropriate methods for determining the piece's characteristics. This involves conducting a modified design based on the original, analysing and describing it, and identifying its components to create new reverse engineering outcomes that align with the desired goals of those artworks. Reverse engineering is considered a theory that aligns with the postmodern era, influencing all areas of life, especially art, to produce renewed and contemporary results characterised by aesthetic and artistic concepts and relationships.

2.3 Methodology Of Reverse Engineering In Ceramics Design

When designing for reverse engineering in ceramic art, it is essential to establish clear goals to achieve the desired results. This process involves several stages:

Determining the Product: Identify whether the focus will be on the entire ceramic piece or just a part of it. This includes selecting the product or component, specifying the raw materials, and analysing information and documented data about the original product. At this stage, the original ceramic piece is disassembled into its parts. The raw materials are identified, and their chemical specifications are determined. The techniques, such as surface treatments and thermal methods, are also established for the desired pieces. Engineering drawings are created to specify the dimensions, and performance tests for the components are designed. The basic specifications of the product are outlined through technical data, including how the components work together, which may involve creating three-dimensional drawings to assist with reverse engineering or modifying the original design. It is also crucial to define the purpose of the reverse engineering process for the ceramic piece, focusing on achieving artistic, expressive, aesthetic, or utilitarian values.

Using Data and Engineering Plans: In this stage, the potter reviews the data obtained from the piece's dismantling and analysis. They then accurately reconstruct it based on the original design. The designs are evaluated for suitability through testing, after which a prototype of the new product is created, tested, and documented for results (Al-Afandy, 2014).

Implementation of the New Product: The implementation stage is completed once the prototype has been successfully tested and its performance verified against the original model. The new product is then presented (Ibrahim, 2006).

Selecting suitable ceramic works for rearranging their basic parts using the concept of reverse engineering.

Reverse engineering is closely connected to the arts, particularly through the concept of redesign. Redesign involves rethinking and creating new artistic formulations by studying the original piece's design, formation, and all aspects. It also requires practical implementation of the new design. This process begins by dismantling the original shape and returning to its foundational elements, such as points, lines, sizes, textures, and design principles like balance, rhythm, and proportions. The goal is to reconstruct a new structure, mirroring the stages of reverse engineering.

Many contemporary artistic trends are linked to redesign, as they break down structures, shapes, and lines to create new compositions. Examples of these trends include assemblage, installation, and abstract art. Redesigning helps the artist understand the artistic direction their formulations represent during implementation. Reverse engineering assists the designer in finding innovative designs that can be applied aesthetically or utilitarian by making necessary modifications. This approach encourages innovation in the design's parts and elements, as it does not rely on a single method and allows the designer flexibility. It is especially useful when there is limited data on the original product.

The designer's attention to detail is crucial; even a small defect in the design can adversely affect the overall concept during reverse engineering. The design process also guides the artist in selecting the appropriate methods for implementation. When working with ceramics that can be rearranged, the ceramic piece should revert to a primary geometric shape (such as spherical, conical, or cubic) or draw inspiration from the shapes in the surrounding environment and historical experiences of different cultures. The ceramic artist selects and utilises these shapes to serve their conceptual goals.

The artist has two main approaches: either simplifying the shapes to achieve a form that aligns with their vision or condensing the formal structure through dismantling and reassembling to match their artistic direction. Modern and contemporary artists often focus on transformable elements, choosing inspirations that their imagination can turn into new artistic images.

One notable modern movement that embodies this approach is Cubism. Saeed (2021) highlights that a key outcome of Cubist art is emphasising geometric shapes—whether square, spherical, cylindrical, or conical—which generate new aesthetic values. Dismantling objects and reshaping them into forms with various geometric surfaces brings a new perspective on the composition of human, animal, or geometric forms. The Cubist compositional system includes principles where artists refer to the reassembly of objects as a "bird's eye view," which transforms perspectives into geometric shapes of diverse sizes and colours.

Many modern art movements adopt traditional forms as structural bases, intentionally reformulating them with a reverse philosophical concept. Artists often rework utilitarian and aesthetic ceramic products by restructuring or restoring their functions. For example, old tableware or other ceramic pieces can be transformed into new, modern shapes by rebuilding them or making plaster moulds. This technique is evident in the work of British artist Eluned Glyn, who draws inspiration from 21st-century ceramic pieces and connects them with the Cubist movement by dismantling and rebuilding items sourced from charity shops. After this process, the pieces are cast and fired in the kiln, as shown in Figure 7.

***Fig. 7.	Artwork by Eluned Glyn***
(https://www.makersguildinwales.org.uk/elunedglyn.html#: ~: text=CERAMICIST%20/%20GWNEUTHURWR%20CERAMEG-, Eluned%20Glyn, -is%20a%20ceramic)

Many artists have deliberately utilised the nature of ceramic material by using porcelain plates to create lighting units, exploiting the transparency of porcelain for use in celebrations or decorative purposes (Figure 8).

Many Chinese artists tend to revive traditional Chinese customs by using porcelain plates as a form of inherited customs in creating ceramic sculptures from clay in various clothing forms, which can produce field artworks or build new forms using those products (Figure 9).

The restructuring and redesign of ceramic products were not limited to artists aesthetically. Many artists, engineers, and craftsmen resorted to reconfiguring some ceramic products to be utilitarian products with new designs, as seen in the shapes (Figure 10) (Al-Hatemi, 2013).

***Fig. 8.	Artwork by Ingo Maurer, Year of Production: 1994***
(https://www.azuremagazine.com/article/10-icons-by-ingo-maurer-the-poet-of-light/)

***Fig. 9.	Artwork by Li Xiaofengm, Year of Production: 2020***
(https://abg.livemuseum.it/li-xiaofeng-porcelain-clothes/)

Fig. 10. Dornback Custom -2016 (http://web.archive.org/web/20160910060034/http:/www.instructables.com/id/Flower-Pot-Smoker-Improved-Lid/?ALLSTEPS)

2.4 Reverse Engineering And Heritage

Heritage strengthens the citizen's connection to his cultural heritage and the importance of identity in providing cognitive and emotional stability for the individual and society. Sustainable development requires the existence of goals that must be achieved socially, economically, and scientifically, and therefore, there must be collective efforts to make our cognitive, architectural, and artistic heritage a valuable place that reflects our personalities and makes us ready for human civilisational achievement to benefit from it.

When talking about heritage, it is necessary to address its preservation, as it is exposed to various factors that change and are renewed with the development of life. There are two main motives to highlight the concept of preserving cultural heritage, which are:

- The development of cultural thought and the importance of preserving heritage.
- The extinction that may befall cultural heritage due (wars, natural disasters, urban expansion) and the reaction to that.

Accordingly, we can address the concept of heritage through:

2.5 Heritage

Al-Jabri mentioned that the term "heritage" originates in Arabic from the word (و.ر.ث - wa.r.th). In Arabic dictionaries, it is synonymous with (inheritance) and (legacy), and the word (heritage) comes to mean cultural and intellectual heritage (Al-Jabri, 1991, p.24).

The glossary (https://www.almaany.com/) defines heritage as "everything left by predecessors, including scientific, artistic, and literary traces, whether material like books and artefacts or spiritual like opinions, patterns, and cultural habits passed down from generation to generation."

Heritage, in general, refers to what our ancestors left behind in terms of human and civilisational values, whether tangible or intangible (material heritage - intangible heritage). In the second half of the last century, the definition of heritage expanded to include individual landmarks and buildings, such as forts and castles. Today, heritage encompasses the entire environment shaped by human activities and achievements throughout history, both material and non-material. As a non-renewable resource, heritage is at risk since it is susceptible to damage or loss and cannot be replaced (Guide to Managing World Heritage Resources, 2016, p.12).

2.5.1 Material Heritage

Includes what is left by the ancestors with historical value, whether fixed (such as historical landmarks, cities, etc.) or movable items (books, manuscripts, photographs, windows and doors, inscriptions and decorations, coins, sculptures, etc.).

The most important elements of material heritage, as defined by the UNESCO Convention "Protection of Cultural and Natural Heritage" in 1972 (Article 1), include:

Archaeological sites: encompass architectural works, murals, sculptures, inscriptions, caves, and all works related to history or art.

Buildings: belonging to different regions with varying architectural styles related to history, art, or science.

Sites: including areas with archaeological significance, human-made works, or those shared between humans and nature, and all works related historically, aesthetically, or ethnologically.

Historical monuments, as mentioned in the Venice Charter of 1964 (Article 1 of the International Charter for the Conservation and Restoration of Monuments and Sites), are not limited to architectural structures but also encompass the built environment and its surroundings, showing evidence of civilization and development linked to historical events (UNESCO, 2022).

2.6 NON-MATERIAL HERITAGE

The UNESCO Convention of 2003 in Paris defined intangible cultural heritage as "the practices, representations, expressions, knowledge, skills – along with the instruments, objects, artefacts, and cultural spaces associated in addition to that – that communities, groups, and in some cases, individuals recognize as part of their cultural heritage." Passed down from generation to generation, it continuously renews itself in line with environmental, natural, and historical interactions, fostering a sense of identity, enhancing human creative capacity, and sustaining continuity through respecting cultural diversity (UNESCO, 2022).

Its areas include:

- Oral traditions (language as a tool for intangible cultural heritage).
- Music.
- Social customs.
- Crafts and traditional products (Awaj, 2019, p.24).

Non-material heritage is vulnerable to rapid deterioration, requiring significant care and attention to preserve and maintain it in alignment with contemporary requirements and ideas.

Given the importance of heritage in our past, present, and future, governments are keen on its preservation to ensure identity continuity, boost tourism and cultural sectors, create job opportunities, and diversify skills for their populations.

Aligned with Vision 2030, the Saudi Kingdom considers culture a fundamental component in enhancing the quality of life for citizens and residents. Saudi Arabia aims to achieve a sustainable modern future while preserving its cultural heritage. It continuously focuses on expanding activities at all levels.

Examples include traditional handicrafts, where Saudi Arabia invests in programs and diverse methods to empower artisans. With deep historical roots, traditional handicrafts hold great importance in sustainable production. These traditional artistic works support the creative economy by attracting artisans to the job market, marketing their creative products, and enhancing skills for the next generation.

As active participants in the global community, we live in a more interconnected and interrelated world than ever before. We work collectively with effective international institutions and entities. We are beginning to see the social, environmental, and economic benefits through the diverse potential that heritage projects possess. Saudi Arabia has undertaken several initiatives, partnerships, and projects to develop and revitalise heritage. One such initiative involves the restoration of local heritage buildings, utilitarian tools, decorative items, and more, focusing on sustainable methods in line with local environmental needs and requirements.

2.7 POTTERY IN SAUDI ARABIA

Pottery is considered one of the ancient traditional artistic professions, based on high skill in manual shaping, starting from preparing the raw material (clay) to shape and inherited from ancient civilisations before history. The heritage of the Kingdom of Saudi Arabia is based on pottery, which is a basic popular craft practised by societies in some of its regions. One of the factors that helped practice it is the availability of local clay and meeting the daily needs for building and shaping cooking utensils and preserving food and liquids, which is considered an extension of ancient civilisations that inhabited the Arabian Peninsula and were influenced by the meeting of civilisations through trade exchange and the caravan journey for Hajj and Umrah. After the discovery of oil, which accelerated the development of industry and trade, significantly affecting the development of traditional industries, including heritage pots, it took several directions. Some of them remained as they were, preserving their cultural heritage with low production, and some developed in terms of shape and material, such as adding decorations, coloured coatings and place of manufacture. Some of them replaced pottery with imported metal and glass pots. Despite this, some regions in the Kingdom, such as the Eastern and Southern regions, still produce these. The craft is inherited by its children; families use it for cooking, eating and drinking, and some are keen to buy it and use it on different occasions. Pottery is one of the permanent phenomena of Saudi society, similar in form and function, and it is sometimes difficult to discover the difference and differentiate between them except through the customs and traditions of the regions and the character of the place and environment (Al-Essa A., 2007). Pottery in the Kingdom is characterised by the association of form with utilitarian function more than aesthetic, represented by the simplicity of form and the lack of decorations, such as using the incision method on the surface of the vessels or by adding colours. Among the pottery pieces known in the Saudi heritage are (pots, jars, decanters, incense burners, and coffee cups...), the external shapes of which are characterised by symmetry and consistency starting from the base to the body and the mouth, and attention to balance and to maintain dimensions, using the potter manual shaping techniques, whether with the wheel or using moulds, interested in the evenness of the wall thickness and the smoothness and fluidity of the surface. In general, interest in decorations and coloured glazes did not appear, and the decorations were very simple, such as pottery vessels for storing liquids and drinking. They can be described, and their shaping methods, aesthetic values, and the extent of their suitability for application can be determined through reverse engineering as follows:

2.8 A Descriptive Study Of Models From Saudi Heritage That Can Be Categorised Under Reverse Engineering

The artist benefits from the steps and stages of reverse engineering in shaping ceramic models inspired by everyday products and developing them according to the purpose for which they were designed. The study aims to observe the original product that underwent reverse engineering in its design. Some Saudi heritage vessels will be presented, which can be studied for the possibility of redesigning and reconstructing them while retaining their original function or adapting them to another function through reverse engineering:

2.8.1 Al-Zeer: (Popular Name Known In The Western Region)

The zeer is a large jar of red clay, shaped on a potter’s wheel into an almost oval form, with a base smaller than the spout opening. It has been used to store water since ancient Egypt, dating back approximately 2500 BC. This practice later spread to many countries, including the Kingdom of Saudi Arabia, particularly in the western region, where the zeer is still used today (Al-Essa A., 1419). Over time, the zeer has been adapted into various shapes and forms to meet daily consumption needs and serve its function effectively (Figure 11).

Fig. 11. Old Jar and Its Modern Adaptation
(https://mawdoo3.com/, https://alzeeralmethali.com/products)

2.8.2 THE INCENSE BURNER

Despite the diversity in its shapes and production sources, the incense burner is considered a distinctive piece in our Arab and Gulf homes. It is associated with perfuming the home and clothes, welcoming guests, and decorating spaces through various shapes, sizes, and materials. Its forms and sizes have evolved, leading to electric and electronic incense burners while maintaining their primary function of perfuming (Figure 12, 13).

Fig. 12. Shapes of Pottery Incense Burners from the Southern Region of Saudi Arabia (Al-Essa, 1988)

Fig. 13. Development of Incense Burners in Form and Technology

2.8.3 ALJABANA (DALLAH)

Aljabana, or coffee-making pot, is a popular name in the southern and northwestern regions of Saudi Arabia (Figure 14, 15). It is considered one of the most commonly used pots by the people of Jazan to make coffee. It is shaped like a clay Dallah and is used to make coffee because it gives the coffee a delicious taste and retains heat for a long time. The pot is specially shaped and exposed to burning in ovens after ensuring the drying process. The shape of the pot is distinguished according to its use. It is a spherical body topped with a long cylindrical neck that ends with a spout. Between the spherical body and the neck is a circular disc handle that helps carry the Aljabana (Al-Essa A., 1419 AH).

Fig. 14. Shapes of Aljabana; or Earthenware Pot (Al-Essa, 1988)

Fig. 15. Shapes Inspired by Aljabana or Earthenware Pot (https://www.smallable.com/)

The various models of functional uses in Saudi heritage have undergone significant development in their form, materials, and implementation methods. This development has created new, advanced forms that serve the same functions. Additionally, existing models can be restructured and adapted for new purposes or purely aesthetic use. To achieve this, it is essential to follow a design methodology based on reverse engineering, as outlined in the earlier stages of this process.

This approach reveals that there is a wide variety of treatments possible for ceramic pieces in general, and specifically for heritage pottery. By re-engineering these pieces and exploring new formulations through various formal, technical, and thermal treatments—including surface thermal treatments and specialized firing methods—ceramic works can be produced that possess both aesthetic and utilitarian values. The artistic vision and style of the potter influences these values.

The researcher believes this topic can serve as a foundation for small projects.

3 Results

Reverse engineering applications can generate a series of new shapes inspired by living or non-living references for contemporary ceramic products.

It is the most suitable method for transferring technology, as it effectively reduces costs and shortens production time.

Reverse engineering promotes innovation rather than adhering to traditional methods in product development.

Its application is not limited to software engineering; it can be utilised in various fields.

The popular heritage of the Kingdom of Saudi Arabia possesses the characteristics necessary for effective reverse engineering operations.

The showcased works from Saudi heritage demonstrate significant re-engineering with new aesthetic concepts while preserving their original functions.

4 Recommendations

Train male and female students in the arts on reverse engineering techniques to support small projects and entrepreneurial activities, reducing imports and enhancing the economic activity of the Kingdom of Saudi Arabia.

Incorporate reverse engineering into the learning process, particularly in the arts, as it aids in reformulating valuable works while preserving their material and moral significance.

Expand research and experimentation in reverse engineering design for folk heritage products, which offer suitable materials and capabilities.

Develop folk industries and crafts to prevent extinction while maintaining their essential characteristics and functions.

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