Introduction of 3D Printing Technology for Fashion Design in Vietnam

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Abstract

3D printing technology is rapidly developing in the world and Vietnam. 3D printing technology is applied in many fields: architecture, construction, medicine, education, and other manufacturing industries such as consumer goods, automobiles, aircraft, and aerospace. Especially, 3D printing technology has developed quite aggressively in the fashion industry. Many brands have applied this technology to print costumes and jewellery. This advancement in technology has helped designers create diversified and abundant fashion products and reduce time-to-market. In Vietnam today, 3D printing technology has been widely applied in several industries, but in the fashion industry this technology has only been partially applied such as sample design and building three-dimensional human body data; the application of 3D printing technology to print clothes has not been implemented yet due to the unsatisfactory printing materials, unsuitable technology, and printers. In this article, the authors study the experiences of some countries in 3D scanning technology, some suitable 3D materials, and printing technologies to test this technology in costume design and product making.

Keywords: 3D design, 3D printing technology, 3D printing materials, costume

1. Introduction

Currently, quick design and prototyping are two of the main processes that benefit from 3D printing technology. 3D printers are useful in the production of limited numbers, for example when some products are needed to test the market or advertise at trade shows [1].

Flynt [2] asserted that 3D printing technology in the fashion industry ensures environmental friendliness and lesser wastage by reducing water usage, textile scraps, water pollution, and air pollution compared to traditional designing. 3D printing technology plays an important role in fast prototyping to meet market requirements.

According to Richardot [3], 3D printing technology enhances remarkably the creative possibilities for fashion designers, by creating a multitude of samples in a short time, while also allowing the creation of accessories attached to a wide variety of fashion products, especially, it can create shapes without molds as traditional design.

2. Research Objectives, Subjects, and Methods

2.1. Research Objectives

The research team identified three objectives to be achieved in this study:

- Building 3D design process;

- Building transition process from 3D sample to 2D design;

- Applying 3D printing technology to print products.

2.2. Research Subjects

In this study, the authors select 3D printing technology in the costume design, and the test-printed costume is a fashion dress for women aged 22-25, living in urban areas.

2.3. Research Methods

To obtain the research objectives, the team used three main methods:

- Synthesize relevant documents and experiences of some countries to build a theoretical basis;

- Expert method: Interview some fashion designers about the current state of 3D technology and the process of transferring ideal sketches;

- Method of testing the process of transferring from ideal sketches to 3D samples, 3D samples to 2D designs, and how to connect software in design to test print products.
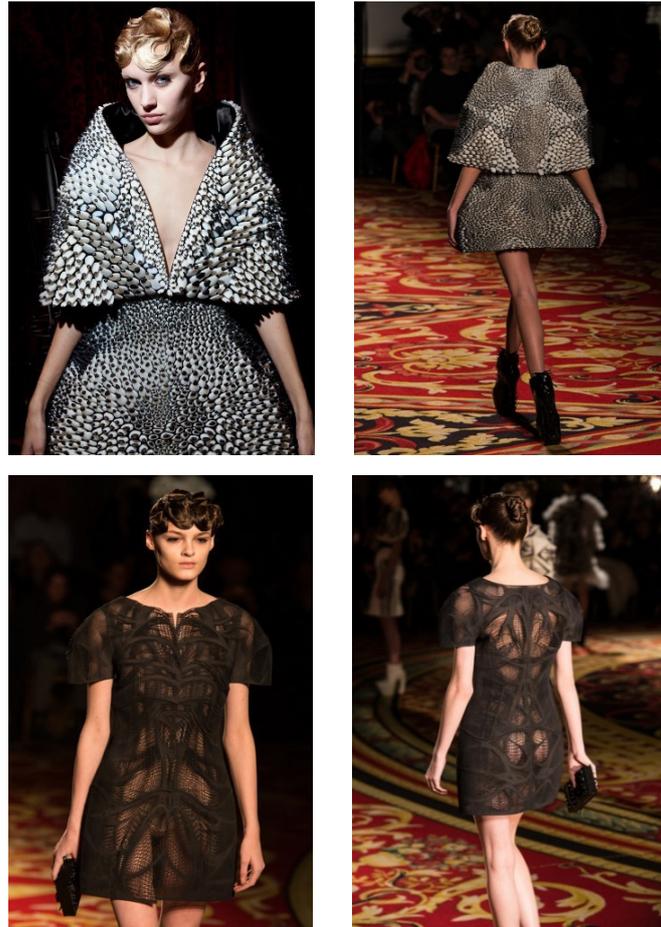
Fig. 1. Fashion dress collection by 3D printing technology.

3. Research Content

3.1. Achievements of 3D Printing Technology in the Fashion Design Industry in the World

In the fashion sector, 3D printing technology helps designers to realize their ideas into specific products. The products are not only used as prototypes but can also be used as other fashion products, although there are some limitations in material and texture. The outstanding advantage is saving raw materials, reducing waste, and personalizing according to preferences.

In 2013, Dutch designers Neri Oxman and Iris van Herpen presented a 3D-printed dress collection at Paris Fashion Week. The fashion dresses in Fig. 1 are assembled by 11 integral pieces, printed from 3D printers, the special thing is that these products have certain softness [4].

Danish Peleg designer has recently used many different technologies, especially 3D printing technology to create fashion dress collections that bring new feelings to users, and are highly appreciated by designers around the world for their aesthetics and creativity. Some of Danish's fashion dresses are shown in Fig. 2 [5].

Fig. 2. Fashion products by 3D printing technology.

In addition, in the world today, many businesses and designers have been using 3D printing technology in fashion designing and manufacturing such as ADIDAS makes fashion shoes; Vojd Studio, a company specializing in fashion accessories manufacturing for high-end fashion products; Endeer - a French entrepreneur, underwear design specialist with 3D printing technology,etc. Julia Koner, a famous designer has used 3D printing technology to create many fashion products and has won many design awards [4]. In particular, the fashion handbag (Fig. 3) is an outstanding 3D-printed product of her designs [6].
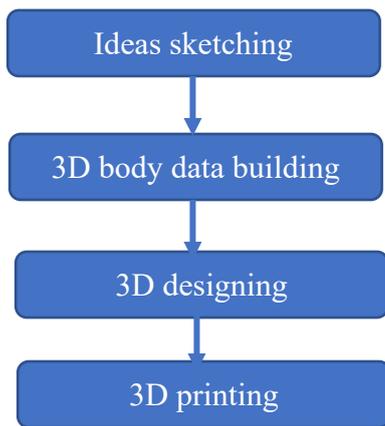
Fig. 3. 3D Printed Hymenium Bag by Julia Körner

Fig. 4. 3D printing technology process in fashion design.

Because designers design and print 3D products individually, 3D printing technology is applied according to the process in Fig. 4 [1].

Overall, 3D technology and 3D printing technology are being studied to improve the printing speed and find suitable materials. Many kinds of research are oriented towards developing organic, environmentally friendly printing materials. The strength of 3D printing technology is fast prototyping, and responding to constant changes from customers. Although there have been researches and applications, today, 3D printing technology still has many limitations on printing materials and printing speed for the fashion sector.

3.2. Three Dimensions Scanning Technology in Costume Design

3D Scanning is a technology developed on the advancement of digital imaging technology. Currently, no one can afford to ignore 3D headlines concerning most fields of life, from medicine, machine manufacturing, biotechnology, and sculpture art to the fashion industry.

3D scanning technology uses the camera system to capture the target object's entire surface to produce 3D images of that object. The scanning system includes one or more light sources, video capture equipment (camera), a computer system, specialized software, and a display screen to simulate the captured images.

Fig. 5 shows 3D scanning technology. This technology allows designers to quickly obtain the overall size of the customer's body and obtain much more accurate parameters than performing manual measurements [7].

This technology allows designers to scan customer images thousands of kilometres away without going directly to the stores, reducing time and money waste (scanning Online).
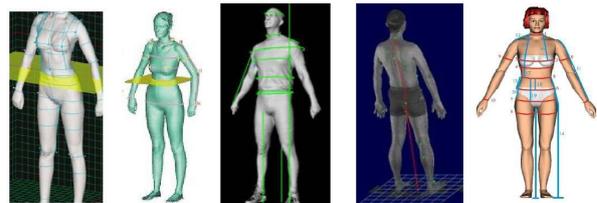

Fig. 5. Customer's body measurements after applying 3D scanning technology.

3.3. Three Dimension Design in Costume Design

3.3.1. Principles of technical design

The 3D design is inherited from 2D, whereby 3D adds depth or thickness to the object. If the 2D design uses two-dimensional planes, *X, Y* then 3D uses n dimensions, and at least 3 dimensions (*X, Y, Z*).

3D technical designers need to master the following basic principles:

Balance: Objects with whether symmetrical or asymmetric or similar correlation in 3D space;

Harmony: Uses the combination of "balance" and colour elements to create a sense of overview;

Rhythm: Same as Artwork 2D correlation;

Emphasis: The subject's emphasis;

Proportion: The design scale depends on the design requirements. Based on the actual situation of the product, the designer determines the appropriate proportion.

3.3.2. Popular supporting 3D design tools in costume design

The tools supporting 3D design are software and equipment. In today's market there is some popular 3D design software for fashion as follows

Vsticher is simple fashion design with high speed and powerful performance. It is chosen by many people because it is easy to install and can be used on many different operating systems, with high efficiency.

Tuka 3d is one of the most favourite designing software today. Previous users highly appreciate

Tuka3d's accuracy. With this software, there is no need to worry about how to correct the colour or resize the design accordingly.

Gerber Accumark is used by many people in the fashion industry. Gerber Accumark can satisfy even the most fastidious designers.

Lectra is the software whose the number of user constantly increased.. Although being only compatible with Windows, it brings a lot of benefits to the users.

3D Marvelous Designer is very popular. With such features as a friendly interface and very fast processing speed, the software optimizes productivity and saving a lot of time for the user.

Clo 3D is a more advanced version of 3D Marvelous Designer. Therefore, Clo is improved and has more features than other 3D design software. This software allows to convert customized body scans like dummy and body to Clo Avata, reduce design preparation time, quickly sketch new designs directly on Avatar, automatically create sample pieces, style outfits with countless complicated layers, accurately simulate all kinds of fabrics with different properties.

Fashion CAD is a simple fashion design software for the Windows platform. This software has been developed and distributed to 50 countries worldwide. Fashion CAD software has practicality, innovation, and flexibility, these are exactly the reasons why this tool is favoured by many designers globally.

Fashion Designer 3D is a fashion design application for the Android platform. Fashion Designer 3D is more like a game than a professional design tool. It allows designers to develop the potential of designing clothes right on a smartphone with an easy-to-use interface.

D.Dress is a software which allows the designing of complex outfits easily and conveniently. Designers will not need to waste materials and time in the prototyping process. This application helps users to make choices to expand the market based on these outfits.

Romans CAD is mainly used in fashion accessories design such as shoes, sandals, and bags. Based on modern functions such as cloud computing, the software updates the latest designs, helping users update the sample designs to create fashion products. With the support of cloud technology, the software helps designers create effectively, improving the connection between designers and manufacturers.

Besides of software, the tools supporting 3D design are equipment. It includes computers, printers, brushes, scanners, lights, etc.

3.4. 3D Printing Technologies in Today's Costume Design

3.4.1. Fused deposition modelling technology

According to Xu and Wu [8], Fused deposition modelling technology (FDM) was first introduced by Crump. FDM 3D printers' working principle involves melting and extruding thermoplastic filaments through a nozzle.

The melted material is deposited on the fabrication platform then cools down and hardens, this process is repeated in a layer-by-layer fashion to build up the 3D structure.

The printing materials are mainly thermoplastics such as polyamide (PA), polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), etc.

3.4.2. Light-sensitive liquid polymer solidification technology

This technology uses ultraviolet (UV) light to treat liquid polymers by layers, and build up 3D structures on a mould or a support plate. There are two types of photochemical technology: stereo lithography apparatus (SLA) and digital light processing (DLP).

Basic principles of SLA: A plastic tank filled with light-sensitive liquid changes from liquid to solid when exposed to certain wavelengths of ultraviolet light. The laser scanning of the layered cross-section is under computer control leaving the layer to be formed. The material layer is coated with liquid resin after the backing plate reduces the height of one layer. Then a new layer is ready to be scanned and the new layer is firmly glued to the previous layer. The above steps are repeated until all parts of the digital model are completed and the 3D model is obtained. The SLA stores and operates photosensitive resin using a direct moving laser method.

3.4.3. Digital light processing

DLP technology uses laser or ultraviolet light as the light source. The light shines through special patterns on the digital mirror device, then the exposed parts are formed and a new layer is completed. The platform raises the height of one layer and the next stage of exposure begins. A 3D solid model is obtained when all layers have been exposed to light [8].

Fig. 6 shows the fundamental principles of DLP. The digital mirror device used as a dynamic mask is the main difference between the SLA and the DLP. SLA and DLP can produce highly accurate structures with complex internal textures and features but have the disadvantage of being limited to using only a single material.
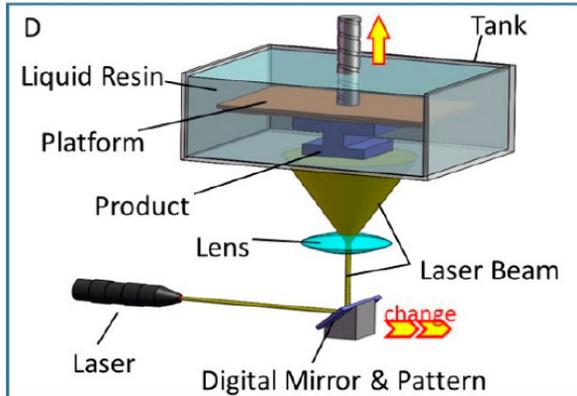
Fig. 6. DLP printing technology.

3.5. 3D Printed Materials for Fashion Designs

According to 3D Plus [9] and Think Smart [10], 3D printing technology uses the following types of materials to create fashion products.

3.5.1. Group of 3D printed plastic materials

Some plastic materials used for 3D printing are shown in Fig. 7.

Fig. 7. 3D printing materials.

- PLA (Polylactic Acid)

Characteristics: This is bio-plastic, easy to print, easy to handle after printing; safe to use, the cheapest price, and most commonly used in today's printing materials. There are usually many different colours for customers to choose from.

Applications: PLA plastics are most commonly used in rapid prototyping such as the printing of handbags, shoes, buttons, and jewellery accessories.

Printable Technology: FDM; SLA; SLS

- ABS (Acrylonitrin Butadien Styrene)

Characteristics: ABS materials have a high melting point and better hardness than PLA. When printing, releases smoke and toxic fumes with an awful smell at high temperatures. ABS printing price is usually more expensive than PLA because it is more difficult to print.

Applications: The intended use is similar to PLA plastic, but is usually selected when the printed pattern needs good strength and heat resistance.

Printable Technologies: FDM, Binder Jetting, SLA, PolyJetting.

- PVA (Polyvinyl Alcohol)

Characteristics: It is a newer type of 3D printing material which is used to create supports that hold 3D prints in place. It is a synthetic and water-soluble polymer that melts at about 200 degrees Celsius and releases some chemicals.

Applications: PVA is used in a standard 3D printer to form parts that support other objects, and it adheres well to a heated glass print base. After printing is complete, it is necessary to soak the water and the dissolved PVA, leaving the rest of the insoluble print. This makes it easy to print complex models needing support or moving parts.

Printable Technologies: FDM, SLS

- Nylon

Characteristics: Nylon was created to replace silk. It has high tensile strength, is non-toxic, and melts at about 250 degrees Celsius. This document has a cheap price and is not corroded by the most common chemicals. Nylon requires higher temperatures to print. Nylon is more difficult to adhere to the print base than ABS or PLA. It usually asks for both a hot inner base and white glue to stick in the printing process

Applications: The use of nylon in the 3D printing process is quite popular recently, it produces prints that are very stiff and shock-resistant. It is widely used in electronics industry, automobile industry, textile industry, fashion industry.Printable Technologies: FDM, Selective Laser Sintering (SLS) and MultiJet Fusion (MJF).

3.5.2. Group of organic materials

- Natural fibre material (Cellulose)

New 3D printed materials, that are developed frequently, are not made from plastic or metal. Scientists are making materials from all kinds of natural substances, such as algae, and coffee grounds and the material that is recently being studied a lot for 3D printing is cellulose. Cellulose is the most abundant organic polymer on the earth, making it an excellent resource for 3D printing. It has an important structural component of the primary cell wall of plants and is secreted by certain types of bacteria, commonly in wood, paper, cotton, cellophane, etc.

- Wood Filament

The materials containing very fine wood grain are combined with PLA and polymer glue, which bind them together. Versions are available in a variety of

woods, from bamboo and ebony to mahogany. These fibres allow changing the colour of the materials by changing the temperature. With higher temperatures, the wood grains have a darker appearance. Wood fibres are printed like PLA filaments. This material needs extra finishing, such as sanding or slight abrasion, to highlight the look of the wood.

The current 3D printing materials still have many limitations for application in life, but it is being studied and developed further, shortly, these materials will be more and more diverse, satisfying many different uses of human.

3.6. Applying 3D Printing Technology to Create Fashion Products

3D printing technology is applied in many fields such as furniture, machine building, robotics, sculpture, home appliances, jewellery and fashion [11]. Although they are different fields that use different types of materials and create different finished products, they are still based on a common process shown in Fig. 8. However, in industrial manufacturing in Vietnam today, it is impossible to directly print products from 3D designs, so we proposed a new process in which 3D designs must be converted to 2D designs before printing.
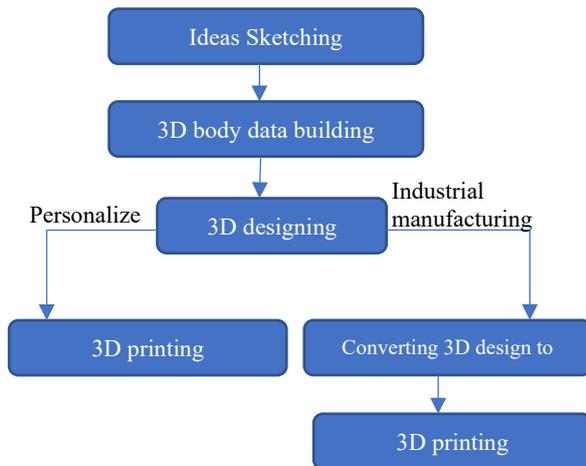
Ideas Sketching
↓
3D body data building
↓
Personalize ← 3D designing → Industrial manufacturing
↓ ↓
3D printing   Converting 3D design to
↓
3D printing

Fig. 8. 3D printing technology process diagram for costume design.

3.6.1. Sketching ideas

In costume design, collecting inspiration and compiling ideas are the first important jobs of the design process. Designers will research the market, the target customers, and trends in colours, materials and designs, …all are described by the designer in visual language as shown in Fig. 9. Based on that table of the target customer, the authors identify the target customer as young women living in the city aged between 22 and 35, with a rich inner mind, easily receptive to new, strange and unique things in fashion to express themselves. They are dynamic, young, love life and full of life and faith. Besides the beauty of the

soul, women at this age are the age of adulthood, the morphological characteristics of the human body are relatively stable and can be considered as the period when the woman's most beautiful body is.

The collection "Tropical" is inspired by white apricot flowers, with a trendy, youthful and elegant style that is the idea throughout the author's aim to serve the target customers. The focus of the collection is on decorative motifs, this dress style has a minimalist style, in line with modern fashion trends.

Then designers sketch the designs. They can create physical sketches or digital works. Fig. 10 shows physical sketches of a fashion collection.
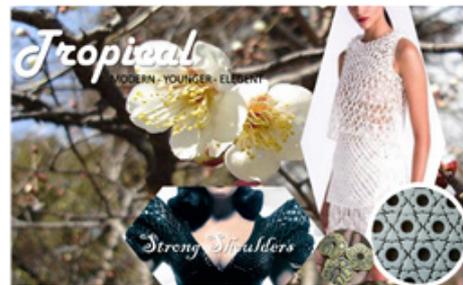

Fig. 9. Ideation.

Fig. 10. Sketching

3.6.2. Building 3D body data

Since each person's body is different, even if two people have the same measurements, it will not be possible to wear the same outfit. Therefore, to have the most accurate design for the target customers, the authors used 3D scanning technology. The model selected in the experiment is a 29-year-old female lecturer who is teaching at the Faculty of Fashion - Hanoi Industrial Textile Garment University. Models wore tight clothes and removed unnecessary fashion accessories to get the most standard measurement data.

The process of constructing 3D model body data include five steps, which is illustrated in the diagram in Fig. 11.

To obtain data for 3D clothing design, it is necessary to scan the female model's body on the 3D scanner model "Go! Scan Spark - Creaform3d" as shown in Fig. 12 [1].
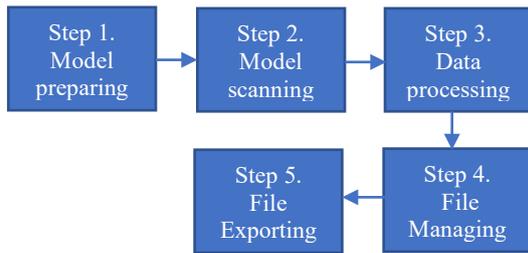
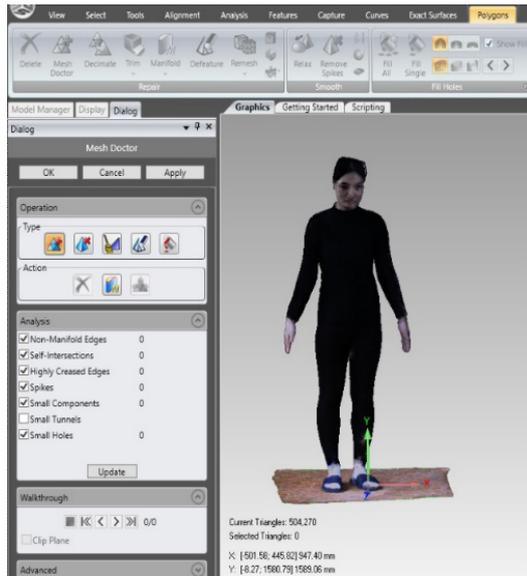Fig. 11. Diagram of Constructing 3D body data.

Fig. 12. Scanning female model.

The model stood in an upright position, and the technician using the 3D scanner moved around the model. Within minutes, the team collected the complete 3D data of the person being scanned. The result was a 3D scan data of a female model and a file of human body measurements exported by the scanner's software. The 3D digitized data that simulated the human body was presented in many forms such as point cloud form and dimension diagram, ...

The research team processed the quality of the scanned data using Geomagic studio software .The purpose is to increase the quality of scan data, minimize errors due to scanner quality, and reduce noise in the scanning process. The data transformations performed are within the allowable tolerances. This step is to adjust the topology of the 3D human body model to meet the requirements in 3D costume design.

3.6.3. 3D sample designing

Before 3D printing, the team performed 3D rendering to check the technical and aesthetic factors as well as the balance of pattern and parameters of the model using 3D scanning technology.
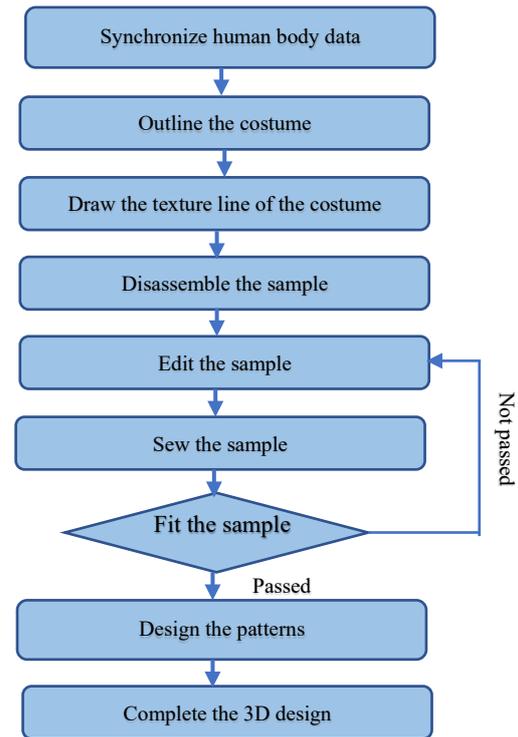

Fig. 13. Diagram of 3D designing.

3D Designing has been supported by many software, but, as mentioned above, Clo 3D is commonly used due to the following reasons:

- It has user-friendly interface, easy to use;

- There are many new features such as transferring custom body scans like dummies and bodies to Clo Avatar; reducing design preparation time, quickly sketching new designs directly on Avatar, automatically generating pattern pieces; creating outfits with countless layers of intricate details; accurate simulation of fabrics with different material properties;

- It has reasonable price;

- There is technical support when there is a higher version upgrade;

- It is to convert to different formats..

The 3D design process is illustrated in Fig. 13, which is accompanied by a diagram of the 3D designing.

From 3D model body data to conducting 3D model design, it is very important to synchronize model body data into 3D design software. Adjusting the avatar shape on the 3D design software to match the scanned model. In case some positions cannot match, continue to edit the parameters. After the adjustment is completed on the 3D working window, the newly created avatar template will appear, whose shape matches the 3D scanned body.

Fig. 14. Completed 3D design.

The final result of the 3D design is a fashion dress worn on a virtual model to test the fit and symmetrical balance of the model as in Fig. 14.

3.6.4. Converting 3D design to 2D design

Currently, the popular 2D design software is Optitex because:

- Optitex is a professional costume design software that enables users to visualize their product before production, while also determining the necessary fabric amount, properties, size, cost, and volume. This saves money, minimizes waste, and maximizes the conservation of raw materials;

- There are many features such as displaying measurement parameters in different ways, scanning fabric when editing and sketching details;

- It is easier to use than other design software;

- There are many powerful intuitive command tools for converting 2D and 3D designs;

- It is compatible with much other hardware and CAD software;

- It enables automatical updating measurement parameters when grading sizes, and changing pattern parameters.

The order of converting from 3D design to 2D design is demonstrated in Fig. 15.

3.6.5. Three dimension printing

The trend of the world is moving towards using natural materials such as cotton, linen, and silk in the fashion industry. However, 3D printing technology has not yet solved the problem of weaving, and projects in this area are still in the experimental phase. The research team therefore used flexible plastic materials suitable for 3D printing equipment available in Vietnam for 3D simulation prints. The plastic material used is highly elastic, providing comfort to users and making it suitable for various activities.
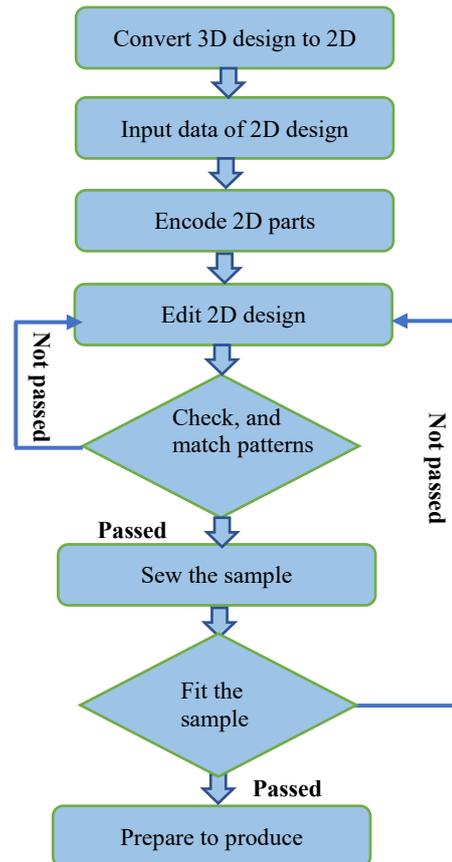

Fig. 15. Diagram of converting 3D design to 2D design.

As analysed above, there are 3D printing technologies that have been developed for different purposes, each with its advantages and disadvantages. Based on the nature and properties of the product after printing, it can be affirmed that most of the above 3D printing technologies can be used to create fashion products. Therefore, depending on the cost of the printer, the printing materials, and the product's purpose, people can choose the appropriate 3D printing technology. For instance,. If the priority is not smoothness and printing speed, then FDM technology may be the best solution for printing products as samples for customers. However, SLA, DLP, or SLS are the most suitable technologies for printing fashion products. We use SLA technology to print this fashion dress. The reason for choosing SLA technology is its fast printing speed and ability to, print on industrial printers in large format. The use of flexible materials, such as high elastic silicon, that are close to nature and organic, adds to the appeal of this technology. The main equipment and tools in 3D printing technology include a 3D printer KINGS JS - 6035- H SLA, a computer with 3D printing programming software, 3D design software, a 3D printing sample disassembly kit, alcohol solution for cleaning products after printing, 3D printed sample washing tank, and 3D printed sample drying tank.
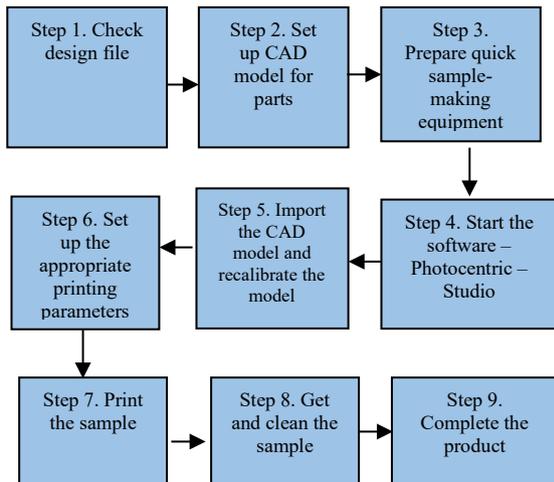
Fig. 16. Diagram of 3D printing process.

Fig. 17. Fashion dress using 3D printing technology.

3D printing technology is currently offered on the market in a variety of technologies, each with its detailed implementation steps. However, the basic 3D printing process includes 9 steps as shown in Fig. 16 [1].

Fig. 17 is a fashion dress that the research team has tested per the 3D printing process proposed by our team: Ideas sketching → 3D body data building → 3D designing → Converting 3D design to 2D → 3D printing

The idea of designing the collection shows the general requirements such as the characteristics of the costume, the aesthetics, the utility in use, the technique, the content of the message, and the meaning

conveyed. Especially, the costumes are new, and unique, and make a strong impression on users.

Costumes applying 3D printing technology were created by the design ideas and processes proposed by the authors as shown in Fig. 16. When using 3D printing technology, all manufacturing stages will be designed and controlled on a computer system. Therefore, saving time and costs and being able to market products faster and sooner to the public instead of having to wait until the product is perfected and having to produce a large quantity, now businesses can market their products through the process of researching and producing products. With 3D printing technology, it is possible to create costumes with difficulty in texture and decoration. The finished product sample has high accuracy, ensuring that it is true to the image design. However, the material to print the costume is not according to the author's idea because it is not soft, and not friendly to the environment and users. It takes a long time to print the product (48 hours) not counting the time to connect the hooks and joints between the product's motifs.

4. Conclusion

3D printing technology is being applied by designers worldwide in the fashion industry, the most popular are 3D design, 3D scanning, and 3D printing [12]. However, currently, the 3D printing speed is very slow, and the 3D printing materials have not met the criteria of fashion such as environmental friendliness, user-friendliness, softness, etc. Currently, 3D design is also quite popular in Vietnam, but 3D scanning and 3D printing have not been exploited yet.

Through research on world experience in 3D scanning technology, 3D materials, and 3D printing technologies suitable for fashion design, the authors have proposed a 3D printing technology process applied to costume design in Vietnam and specific processes such as 3D body data building, 3D designing, 3D to 2D design converting. Applying 3D printing technology and choosing the right materials to print fashion dresses with precious and sophisticated textures and pattern designs

Because 3D printing technology and materials in Vietnam are still limited, it is impossible to choose diverse and suitable materials for the design and at the same time, it has not been able to choose many 3D printing technologies to compare and find out the most optimal solution.

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