

RUBANKA MYKOLAKyiv National University of Technologies and Design
<https://orcid.org/0000-0003-2367-0333>
e-mail: rubanka.mm@knutd.edu.ua**VYNNYCHUK MARIIA**Academy of Design and Technology (DTA)
<https://orcid.org/0000-0002-5126-6568>
e-mail: m.vynnychuk@ukr.net**VYDOLOB DMYTRO**Union of Jewelers of Ukraine
<https://orcid.org/0000-0002-2969-2210>
e-mail: dm.vydolob@gmail.com**POLISHCHUK OLEH**Khmelnyskyi National University
<https://orcid.org/0000-0002-9764-8561>
e-mail: opolishchuk71@gmail.com**KAMENIEV VOLODYMYR**Khmelnyskyi National University
<https://orcid.org/0009-0004-4643-336X>
e-mail: oxomaneoxoma@gmail.com

THE FEASIBILITY OF USING MODERN SOFTWARE FOR THREE-DIMENSIONAL MODELING IN THE JEWELRY INDUSTRY

The article considers the features of the jewelry designer's work at the design stage of the creation of jewelry. The feasibility of using the Rhinoceros 3D modern software for three-dimensional NURBS modeling is proved. The scientific novelty consists in the development of engineering methods of jewelry design. The most common computer programs for three-dimensional modeling of various levels of complexity are listed. A complex of general scientific approaches has been used to conduct the research, namely the visual-analytical approach, the system-informational approach, modern methods of analysis of mechanical systems, analysis of scientific literature as well as the method of classifications. The most important factors that directly affect the process of creating jewelry are singled out. The algorithm for creating a three-dimensional model of a single-profile ring with engraving by using the Rhinoceros 3D software is proposed and its main stages are characterized. Certain recommendations for the effective use of the Rhinoceros 3D software for three-dimensional NURBS modeling in the jewelry industry are formulated.

Keywords: design-projecting, jewelry, algorithm, 3D model, ring, software product, Rhinoceros 3D.

РУБАНКА МИКОЛА

Київський національний університет технологій та дизайну

ВИННИЧУК МАРІЯ

Академія дизайну та технологій (DTA)

ВИДОЛОБ ДМИТРО

Союз ювелірів України

ПОЛІЩУК ОЛЕГ, КАМЕНЕВ ВОЛОДИМИР

Хмельницький національний університет

ДОЦІЛЬНІСТЬ ВИКОРИСТАННЯ СУЧАСНОГО ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ ДЛЯ ТРИВИМІРНОГО МОДЕЛЮВАННЯ У ЮВЕЛІРНІЙ СПРАВІ

Метою дослідження, висвітленого у цій публікації, є оцінка доцільності використання програмного забезпечення для тривимірного NURBS-моделювання Rhinoceros 3D у ювелірній справі на прикладі створення моделі однопрофільної каблучки з гравіруванням. Акцентовано увагу на проектному етапі створення ювелірних виробів. При проведенні досліджень використано комплекс загальнонаукових підходів: візуально-аналітичний, системно-інформаційний, сучасні методи досліджень механічних систем, аналізу наукової літератури та метод класифікацій. Наукова новизна полягає у розвитку інженерних методів проектування ювелірних виробів. Перелічено найбільш поширені комп'ютерні програми для тривимірного моделювання різних рівнів складності. На основі аналізу роботи дизайнера-ювеліра на проектному етапі створення ювелірного виробу встановлена доцільність використання комерційного програмного забезпечення для тривимірного NURBS-моделювання Rhinoceros 3D, частково розкрито особливості його використання та основні функціональні можливості. Виокремлено найбільш важливі фактори, що безпосередньо впливають на процес створення ювелірних виробів. Запропоновано алгоритм створення тривимірної моделі однопрофільної каблучки з гравіруванням в програмному середовищі Rhinoceros 3D та охарактеризовано основні його етапи. Сформульовано певні рекомендації щодо ефективного використання програмного забезпечення для тривимірного NURBS-моделювання Rhinoceros 3D у ювелірній справі, зокрема на проектному етапі створення ювелірних виробів. Встановлено, що використання сучасного програмного забезпечення дозволяє дизайнерам-ювелірам суттєво зменшити трудомісткість технологічних процесів виробництва ювелірних виробів. Запропонований алгоритм побудови 3D моделі однопрофільної каблучки з гравіруванням може знайти практичне застосування на конкурентоспроможних підприємствах галузі, які використовують в своїх технологічних процесах виробництва сучасні комп'ютерні програми для тривимірного моделювання.

Ключові слова: дизайн-проекування, ювелірний виріб, алгоритм, 3D модель, каблучка, програмний продукт, Rhinoceros 3D.

Introduction

The price policy of a finished jewelry is determined by a lot of factors, namely the consumption of materials and their cost, the labor intensity and the complexity of the production process, the qualification of the craftsman, the reputation of the brand, etc. Of course, for a true master-virtuoso of jewelry, a priori, there should not be any particular difficulties at all stages of technological process of production. However, it is important to take into account the time spent on the production of a product unit. This issue is especially relevant at the design stage of the creation of a new jewelry product, when the design, in particular, aesthetic characteristics of the product are determined, the necessary sketches are developed, and design and technological development is carried out [1]. The complexity and tension of performing stated tasks at the design stage of creating jewelry are significantly simplified by using modern specialized software for three-dimensional modeling and visualization by the jewelry designer.

Problem statement

In our days, the market of software products for three-dimensional modeling is quite saturated. So a novice designer is often faced with the difficult choice of the most suitable computer program for three-dimensional modeling and visualization. The capabilities of the selected software product must fully meet the up-to-date requirements of graphic design, in particular design-projecting of jewelry [2].

A competitive, multi-functional software product should perform the defined tasks of any complexity and help implement the creative ideas of jewelry designers in creating 3D models for further use.

The purpose of the study covered in this publication is to assess the feasibility of using Rhinoceros 3D software for three-dimensional NURBS modeling in the jewelry industry on the example of creating a model of a single-profile ring with engraving.

Methodology

A complex of general scientific approaches has been used to conduct the research, namely the visual-analytical approach, the system-informational approach, modern methods of analysis of mechanical systems, as well as the method of classifications.

The scientific novelty consists in the development of engineering methods of jewelry design. The algorithm for creating a 3D model of a single-profile ring with engraving using the Rhinoceros 3D software for three-dimensional NURBS modeling is proposed and its stages are characterized.

Practical significance

The algorithm for creating a 3D model of a single-profile ring with engraving is developed. Specific recommendations for the effective use of Rhinoceros 3D software for three-dimensional NURBS modeling in the jewelry industry are formulated.

Presentation of the main material

The most common computer programs (Fig. 1) that allow creating 3D models of different complexity are Autodesk 3ds Max (3d Studio MAX), SolidWorks, Rhinoceros 3D, ZBrush, PTC Creo Parametric, TopSolid Design, Autodesk Fusion 360, and Computer Aided Three-Dimensional Interactive Application (CATIA). The features of use and functionality of some of the abovementioned software products are given in the scientific work [2].

At the design stage of the jewelry designer's work, a computer program for three-dimensional modeling can serve as a tool. And it does not matter, what program the user has chosen, because he must be able to perform geometric modeling of details, mechanisms, and constructions in the form of spatial models and projection images. To use a computer program effectively, a jewelry designer must have spatial imagination, be able to perform pencil drawings, and know the established rules and regulatory standards. The computer program does not perform work instead of the user, it only significantly simplifies this process.

A rational choice of software determines the complexity of the process of creating a jewelry model. With a strong desire, it is possible to create something like a detail drawing using a primitive (simple) graphic editor (for example, Paint). The same thing can be done, but more qualitatively and with significantly less time spent, using a modern, specialized, powerful graphic editor that is developed specifically for this task (i.e. AutoCAD, PTC Creo Parametric, etc.) [3, 4].

According to the authors of the article, the Rhinoceros 3D commercial software for three-dimensional NURBS modeling, developed by Robert McNeel & Associates, the United States of America [5], is the most adapted software for the jewelry industry from the above list of software products for three-dimensional modeling. Such software has a powerful and at the same time simple and intuitively understandable set of functions necessary for creating a 3D model of jewelry of any complexity [6]. The Rhinoceros file format (*.3dm) is useful for exchanging NURBS geometry [7].

The proposed algorithm for design-projecting a model of a single-profile ring with engraving by using the Rhinoceros 3D software to increase convenience, visualization and achieve more powerful functionality and the degree of adaptation is as follows:

- to create a new project using the template "Small Objects – Millimeters";
- to enable binding by the endpoints (End), middle points (Mid), quadrants (Quad), and central points (Center);
- to draw an arc ("Arc: Start, End, Radius" tool) between two points with coordinates (-5.5; 10); (5.5; 10) and with a radius of 6.54 mm (Fig. 2, a) in the context window "Right";

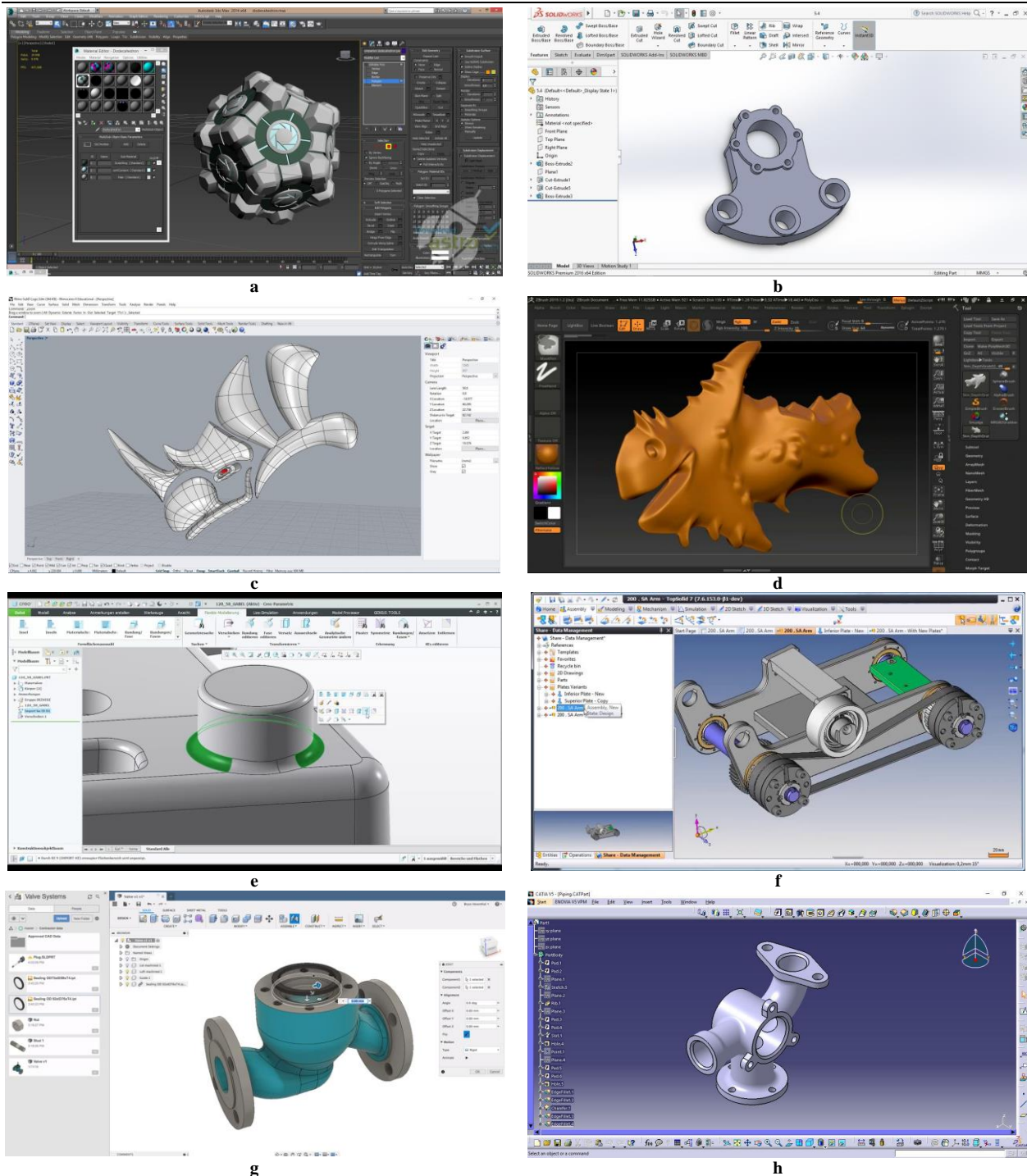


Fig. 1. The working windows of the programs for three-dimensional modeling: a – Autodesk 3ds Max; b – SolidWorks; c – Rhinoceros 3D; d – Zbrush; e – PTC Creo Parametric; f – TopSolid Design; g – Fusion 360; h – CATIA

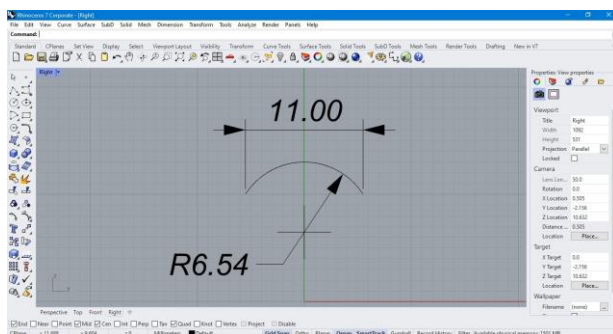
- to connect the beginning and the end of the created arc with a straight line in the context window “Right”, using the tool “Polyline”. To round the sharp edges of the future profile of the ring using the tool “Fillet Curves”. The radius of rounding is 0.25 mm;
- to join all curves into one contour in the context window “Right” using the command “Join”;
- to create a rotation object relative to the axis y at the angle of 360^0 (Fig. 2, b) in the context window “Right” using the command “Surface-Revolve”;
- to create an ellipse of the specified dimensions (Fig. 2, c) with the starting point in the center of coordinates in the context window “Top” using the tool “Ellipse: From center”. Then apply the command “Edit-Rebuild” to the created ellipse;
- to turn on the control points editing mode (“Show object Control Points” tool) in the context window “Top” and give the ellipse the appearance according to the drawing;
- to move the curve created in the previous step by 15 mm along the axis z in the context window “Front”. Then turn over to the display mode “Shaded”;

- to project a curve on the surface of the ring (Fig. 2, d) in the context window “Perspective” using the command “Curve-Curve From Object-Project”;
- to add two points in the context window “Top”, which will be used to divide the form into parts using the “Edit-Control Points-Insert Kink” command. Use the tool “Explode”;
- to highlight both curves in the context window “Perspective” and to extrude the shape in both directions (Fig. 2, e) by 0.25 mm using the command “Surface-Extrude Curve-Straight”;
- to fill in the form at the top and bottom (Fig. 2, f) in the context window “Perspective” using the command “Surface-Blend Surface”;
- to join all created surfaces into one object in the context window “Perspective” using the tool “Join”;
- to create a polar array of 32 copies with the point of the center of rotation at the origin (Fig. 2, g) in the context window “Front” using the command “Transform-Array-Polar”;
- to delete the part of the body (32 arrays) of the ring in the context window “Perspective” using the tool “Boolean Difference”;
- to give the ring a color scheme (Fig. 2, h) in the context window “Perspective” in accordance with the original drawing. Then turn over to the display mode “Rendered”.

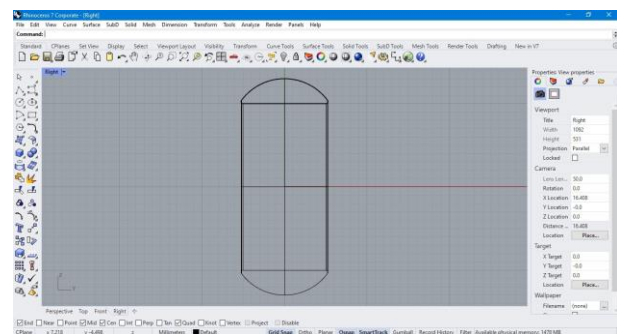
Before saving the obtained result of the creation 3D model of jewelry using the Rhinoceros 3D software, it is necessary to make check for errors, which, if any, must be corrected. The types of files for saving the created jewelry model are the follows: Rhino 3D model (*.3dm), Stereolithography (*.stl), AutoCAD drawing file (*.dwg), 3D Studio (*.3ds), Adobe Illustrator (*.ai), Raw Triangles (*.raw) and many others.

The STL (*.stl) file format is widely used to save three-dimensional models for use in additive technologies [8 - 11]. The created 3D model can be printed on a 3D printer using a polymer material [12–14].

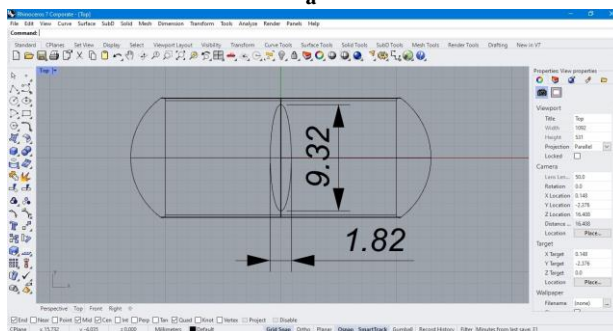
If necessary, the jewelry designer will be able to determine the mass characteristics of the object (i.e. the center of mass of the model, the volume of the material needed to create the entire model or its individual parts, etc.), using a set of commands in the “Analyze” tab, switch to visualization mode and save the obtained result in the formats *.bmp, *.jpg, *.png, *.tga, *.pcx or *.tif.



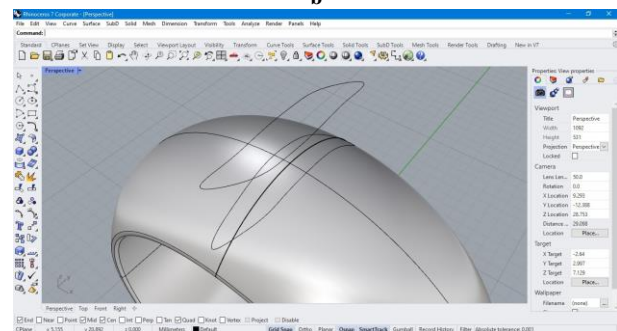
a



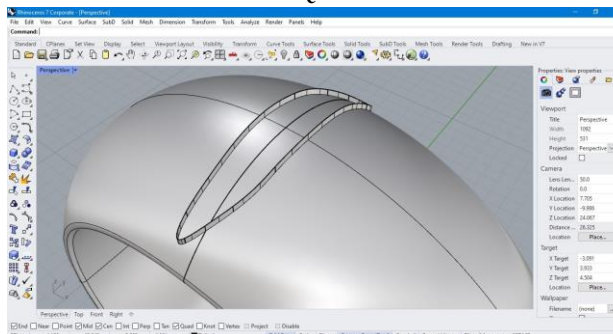
b



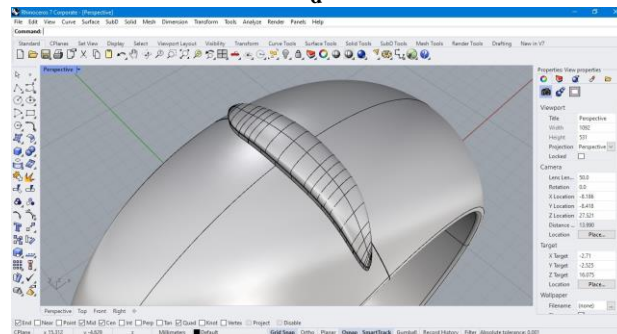
c



d



e



f

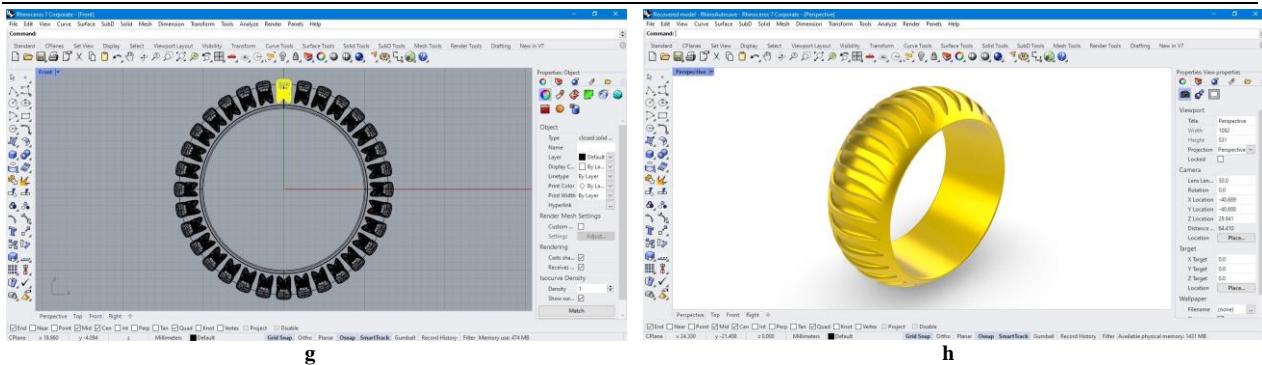


Fig. 2. The working windows of the Rhinoceros 3D program for design-projecting a model of a single-profile ring with engraving: a – the use of the tool “Arc: Start, End, Radius” to draw an arc; b – the use of the command “Surface-Revolve” to create a rotation object relative to the axis y at the angle of 3600; c – the use of the tool “Ellipse: From center” to create an ellipse; d – the use of the command “Curve-Curve From Object-Project” to project a curve on the surface of the ring; e – the use of the command “Surface-Extrude Curve-Straight” to extrude the shape; f – the use of the command “Surface-Blend Surface” to fill in the form; g – the use of the command “Transform-Array-Polar” to create massive objects; h – the final result

Conclusions

Having analyzed the obtained results, it is possible to conclude that:

- based on the analysis of the features of the jewelry designer's work at the design stage of the creation of jewelry, the feasibility of using modern software is proved;
- on the example of the proposed algorithm for design-projecting a model of a single-profile ring with engraving, it is stated that the Rhinoceros 3D commercial software for three-dimensional NURBS modeling, developed by Robert McNeel & Associates, the United States of America, is one of the most adapted software for the jewelry industry;
- the use of modern software allows jewelry designers to significantly reduce the labor intensity of technological processes of jewelry production, in particular at the design stage of the creation of jewelry;
- the proposed algorithm for designing a 3D model of a single-profile ring with engraving can be practically implemented at the enterprises of the industry, which use modern computer programs for three-dimensional modeling in their manufacturing processes.

Література

1. Винничук М.С., Колосніченко М.В. Особливості дизайн-проекування ювелірних виробів. Актуальні проблеми сучасного дизайну : збірник матеріалів Міжнародної науково-практичної конференції (20 квітня 2018 року). Київ : КНУТД, 2018. Том 1. С. 320–323.
2. Рубанка М. М., Остапенко Н. В., Рубанка А. І. Особливості застосування сучасних програм у дизайн-проекуванні ювелірних виробів. Art and Design. 2019. № 4 (08). С. 109–118.
3. Key features of AutoCAD 2024. URL: <https://www.autodesk.com/products/autocad/features>.
4. Creo Parametric - незамінне тривимірне параметричне рішення CAD. URL: <https://tpolis.com/ptc/creo/modules.php>
5. Rhinoceros 3D. URL: https://uk.wikipedia.org/wiki/Rhinoceros_3D
6. New in Rhino 7. URL: <https://www.rhino3d.com/7/new/>
7. NURBS. URL: <https://uk.wikipedia.org/wiki/NURBS>
8. Андрощук Г. О. Адитивні технології: перспективи і проблеми 3D-друку. Наука, технології, інновації. 2017. № 1. С. 68-77.
9. Назаркевич Є. Адитивні технології та 3D моделювання в ювелірному мистецтві. Народна творчість та етнологія. 2021. № 2 (390). С. 113–122.
10. Що таке файл STL? URL: <https://docs.fileformat.com/uk/cad/stl/>
11. Файли STL. URL: <https://www.adobe.com/ua/creativecloud/file-types/image/vector/stl-file.html>
12. Винничук Марія. Стилістика прикрас і доповнень як засіб гармонізації художнього образу костюма: теорія та практика : монографія. Tallinn : Disaini ja tehnoloogia akadeemia, 2021. 450 с.
13. Choi K. A Study on the Characteristics of 3D Printing Jewelry Design Utilizing with Fractal Geometry. Journal of Fashion Business. 2017. № 21(5). С. 136-150.
14. Jung-Soo Lee, Kyung-Chul Cha. A study on the manufacture of dissimilar metal jewelry using 3D printer. Journal of the Korean Crystal Growth and Crystal Technology. 2016. Vol. 26. № 1. P. 19-22.

References

1. Vynnychuk M.S., Kolosnichenko M.V. Osoblyvosti dyzain-proektuvannya yuvelirnykh vyrobiv. Aktualni problemy suchasnoho dyzainu : zbirnyk materialiv Mizhnarodnoi naukovo-praktychnoi konferentsii (20 kvitnia 2018 roku). Kyiv : KNUITD, 2018. Tom 1. S. 320–323.
2. Rubanka M. M., Ostapenko N. V., Rubanka A. I. Osoblyvosti zastosuvannya suchasnykh prohram u dyzain-proektuvanni yuvelirnykh vyrobiv. Art and Design. 2019. № 4 (08). S. 109–118.
3. Key features of AutoCAD 2024. URL: <https://www.autodesk.com/products/autocad/features>.
4. Creo Parametric - nezamynne tryvymirne parametrychne rishennia CAD. URL: <https://tpolis.com/ptc/creo/modules.php>

-
5. Rhinoceros 3D. URL: https://uk.wikipedia.org/wiki/Rhinoceros_3D
 6. New in Rhino 7. URL: <https://www.rhino3d.com/7/new/>
 7. NURBS. URL: <https://uk.wikipedia.org/wiki/NURBS>
 8. Androshchuk H. O. Adyativni tekhnolohii: perspektyvy i problemy 3D-druku. Nauka, tekhnolohii, innovatsii. 2017. № 1. S. 68-77.
 9. Nazarkevych Ye. Adyativni tekhnolohii ta 3D modeliuвання v yuvelirnomu mystetstvi. Narodna tvorchist ta etnolohiia. 2021. № 2 (390). S. 113–122.
 10. Shcho take fail STL? URL: <https://docs.fileformat.com/uk/cad/stl/>
 11. Faily STL. URL: <https://www.adobe.com/ua/creativecloud/file-types/image/vector/stl-file.html>
 12. Vynnychuk Mariia. Stylistyka prykras i dopovnen yak zasib harmonizatsii khudozhnoho obrazu kostiума: teoriia ta praktyka : monohrafiia. Tallinn : Disaini ja tehnoloogia akadeemia, 2021. 450 s.
 13. Choi K. A Study on the Characteristics of 3D Printing Jewelry Design Utilizing with Fractal Geometry. Journal of Fashion Business. 2017. № 21(5). S. 136-150.
 14. Jung-Soo Lee, Kyung-Chul Cha. A study on the manufacture of dissimilar metal jewelry using 3D printer. Journal of the Korean Crystal Growth and Crystal Technology. 2016. Vol. 26. № 1. P. 19-22.