COMPUTATIONAL MODELING OF MULTI-PURPOSE AMPHIBIOUS AIRCRAFT BE-103

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ABSTRACT

The paper is dedicated to the aspects of 3D computational modeling of Be-103 amphibious aircraft. The paper contains initial Figures and drawings; the computational modeling is performed in 3 ds Max 3D graphic modeling system. Models of amphibious aircraft structural components are produced by polygonal extrusion process. Shading is performed at the sub-objects level as well as assignment of materials. Figures illustrating realistic rendering of amphibious aircraft 3D-model are presented as well.

Keywords: 3D computational modeling, Amphibious aircraft, Projection drawings, Construction of amphibian aircraft, Polygonal extrusion method, Modeling of fuselage, Wing, Tail unit, Shading, Rendering.

Contribution/ Originality

The main contribution of this article is to create a method of designing from the initial sketch-es to photorealistic model of amphibious aircraft. Polygonal modeling method has advantages in the designing of complex engineering objects. For high-quality rendering of the final model uses an improved calculating method of lighting.

1. INTRODUCTION

Hydro-aviation is effectively used at water areas located all over the world, which are hard-to-reach by other means of transport. An important role of hydroaviation in the field of island states tourism development is described in articles [1, 2]. An amphibious aircraft may use either ground runways and inland water bodies or offshore zones for take-off and landing, this feature belongs to universal qualities of amphibious aircrafts. This work is dedicated to aspects of Be-103 amphibious aircraft 3D computational modeling. This aircraft was developed by Beriyev Aircraft Company.

Modeling state-of-the-art technologies are traditionally applied for aircraft designing. The Paper [3] describes the parametric designing of aircraft aerofoil surfaces with the software based on smooth surfaces. The paper [4] is dedicated to aspects of high-precision software tools to be implemented to optimize the design process when developing an aircraft design. The paper [5] describes particularities of the aircraft design based on the lofting method. Quite a detailed description of modern automated design systems is given in the book [6]. Particularities of preliminary and conceptual aircraft design are given as well.

Designing of Be-103, the light amphibious aircraft, began in the early 1990's at Beriev Aircraft Company [7] (Fig. 1). The main objective of the project was to create the multi-purpose amphibious aircraft for local airlines. A low skimming foil was the distinctive feature of this project. Such configuration gave an essential benefit in stability

while moving on the water during the take-off and landing, and increase of the wing lift force due to the screen effect. Through other analogs found worldwide we can mark Airmaster Avalon-680, an amphibious flying boat produced in USA, and Do-24, an amphibious aircraft produced by German company Dornier Seastar [8].

Be-103, the light multi-purpose amphibious aircraft, may be effectively used in coastal zones, on the rivers and lakes [1, 2]. The aircraft is a low-wing monoplane that has vertical and horizontal tail plane and tricycle landing gear with a nose wheel. The power plant consists of two piston engines mounted on the horizontal pylons on both sides of the body. Aircraft sea worthiness is sufficient to withstand the roughness up to two points (wave height to 0.5 m). The aircraft can be operated on the water bodies subject to their depth is not less than 1,5 m and the length is not less than 600 m, and on the ground airfields. Maximum take-off weight of Be-103 amphibious aircraft is 2270 kg, maximum cruise speed is 240 km/h [9]. The aircraft can take 4-5 passengers or cargo of 385 kg. In addition to passenger-and-freight configuration, following options are available: sanitary, environmental monitoring of water areas, fire-prevention monitoring of forest.

To develop the 3D-model of amphibious aircraft can be used various software products and modeling methods. The capabilities of 3ds Max three-dimensional simulation graphical system will be implemented in the present work. The graphic system, 3ds Max, is a type of versatile tool that can interact with many CAD systems [10].

Fig-1. Be-103 amphibious aircraft [7]
Source: Source presented in picture caption: airline's website ref. The Official Website of the Beriev Aircraft Company [7]

2. MODELING METHODS AND STAGES

2.1. Preparation of Initial Illustrations

To create the preliminary design, a set of graphic information should be available in the form of photos (Fig. 1) and drawings of object modeled (Fig. 2). Be-103 amphibious aircraft has following overall dimensions: wingspan 12.72 m, length 10.56 m, height of 3.76 m. The processes of 3D-modelling starts from creation of three perpendicular planes, then the images of projection drawings are placed in these planes [11]; [12]. Unlike article [11] all stages of three-dimensional simulation of the amphibian aircraft structural segments as well as specific features of development and assignment of the materials, scene illumination sources installation, will be presented in the this work. This method was tested during the computational modeling of Be-200 amphibious aircraft [13].
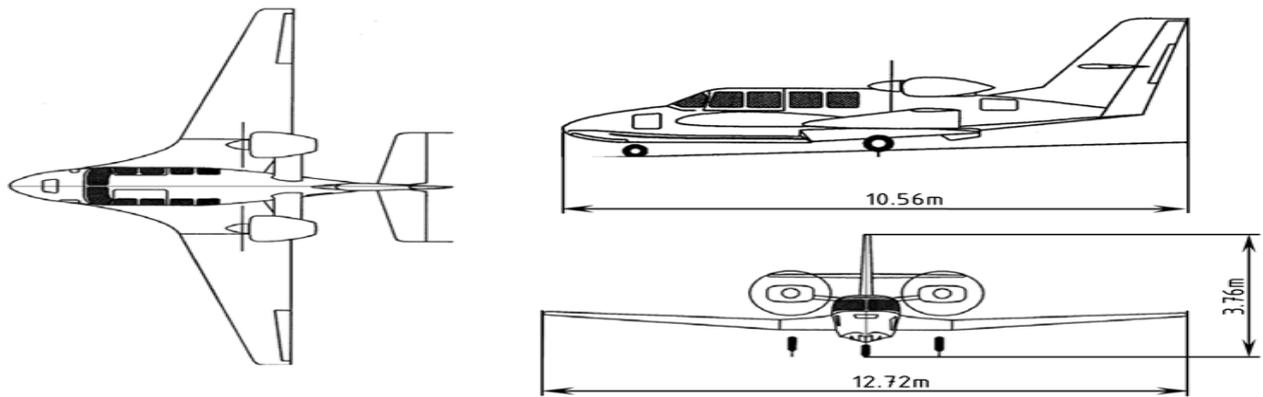
Fig-2. Be-103 orthogonal projections
Source: The author's original development, aspect ratio of figure is distorted

To describe the complete three-dimensional simulation procedure, the flow chart of the main design stages is provided in Fig. 3:

- preparation of initial projections drawings (Fig. 4);
- development of three-dimensional projection planes;
- stage-by-stage modeling of the structural parts of the amphibian aircraft;
- assembly of the final three-dimensional model;
- creating and assignment of the materials and textures (shading);
- selection and installation of the light sources;
- rendering of the overall scene.

Fig-3. Flow chart of the main design stages
Source: The author's original development

2.2. Creating a Three-Dimensional Projection Planes

To create a model of the body surface, will be used a method of polygonal extrusion. A half of the model is developed along the longitudinal axis, taking into consideration the object's symmetry, this will simplify the process. In this case will create the right half of the model, the left one will be made automatically at the final stage.
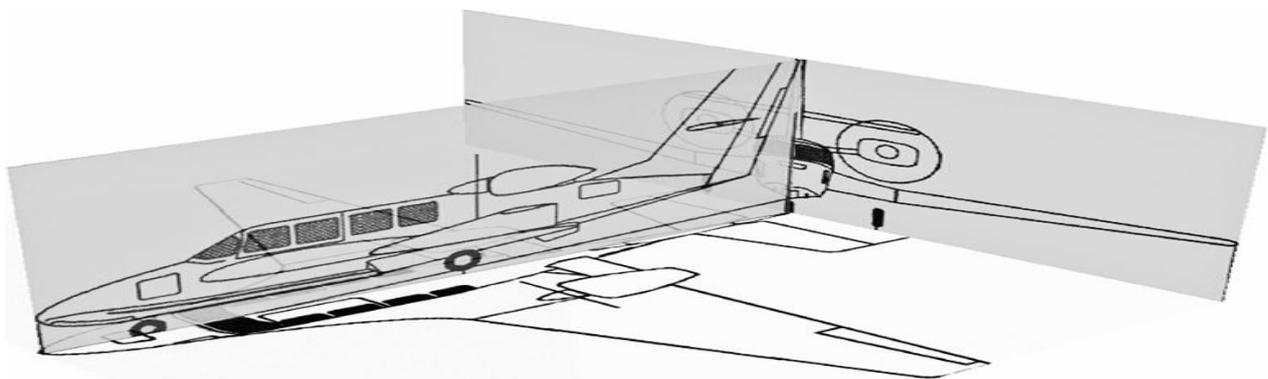

Fig-4. Creation of three mutually perpendicular planes
Source: The author's original development, aspect ratio of figure is distorted

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Modeling begins by creating of the initial polygon. The polygon then becomes a start point for the entire body. Further performed consistently replicate a side of the polygon; this stage is carried out by repeated visible body projection. The result of construction is shown on the Fig. 5. While extruding the sides it is important to keep the constant number of polygons along the body to avoid further problems related with geometry and subsequent finishing of the model. Therefore at the initial stage the minimum quantity of polygon sides is assigned, because it is easier to add required number of additional sides than to delete existent sides if inadequate number is met.
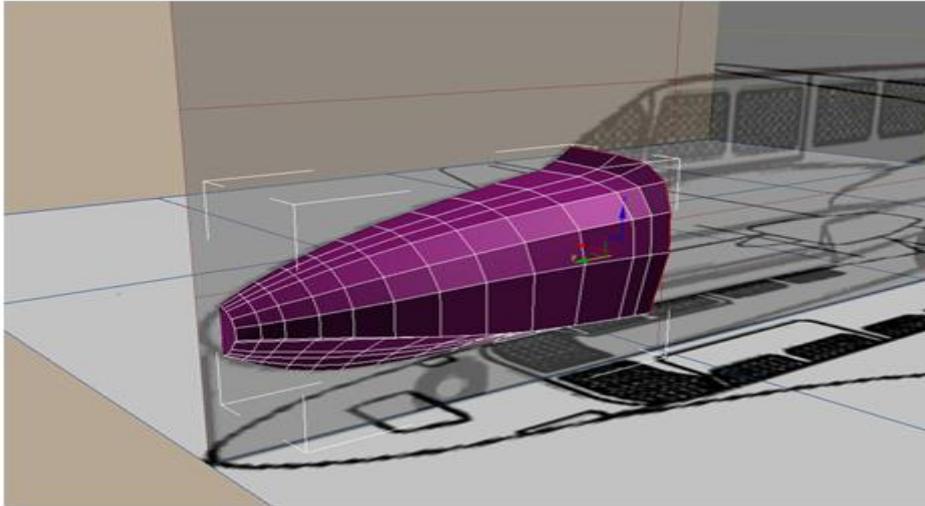

Fig-5. Creation of initial polygon in the forebode

Source: The author's original development

2.3. Modeling of the Fuselage

At the next stage we will replicate the contours of the aircraft body (see Fig. 6) applying he method of sequential extrusion to the group of polygons and subsequent projections alignment, While increasing the number of polygons moving along the body axis, must be collate the extrusion process with aircraft projections in all three planes.
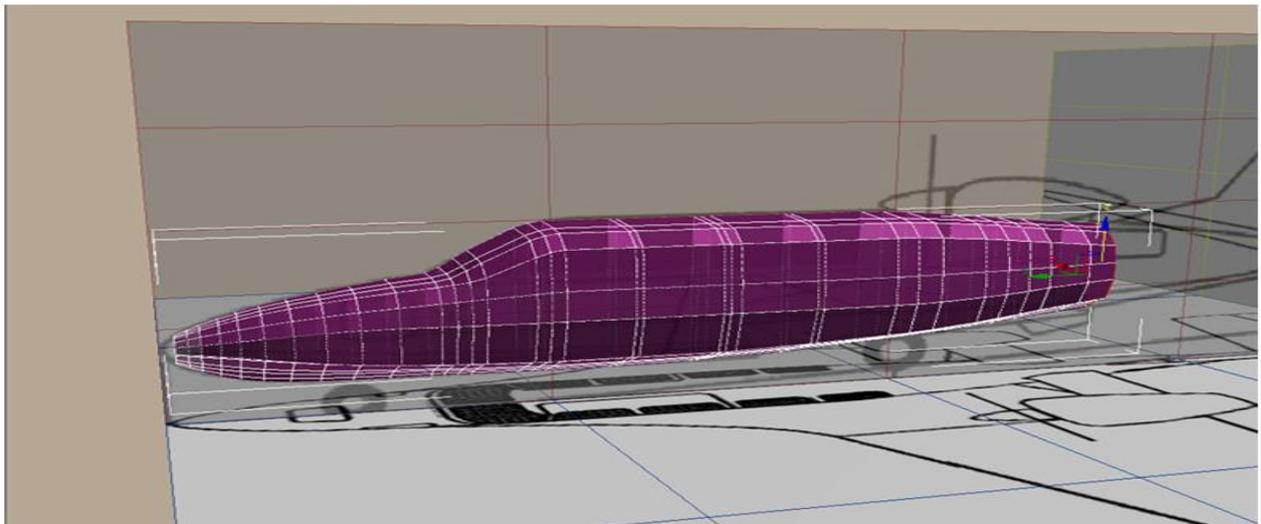

Fig-6. Sequential body extrusion

Source: The author's original development, aspect ratio of figure is distorted

With the approaching to the tail, a grid density increases, keeping constant number of polygons in a section but reducing the distance between tops. The end of the after body is closed by the polygon, then the initial faceted

model is smoothed with the use of respective command. The obtained model is not quite a body yet; it is only a workpiece to obtain all the other parts and components thereafter by polygon extruding method (Fig. 7).
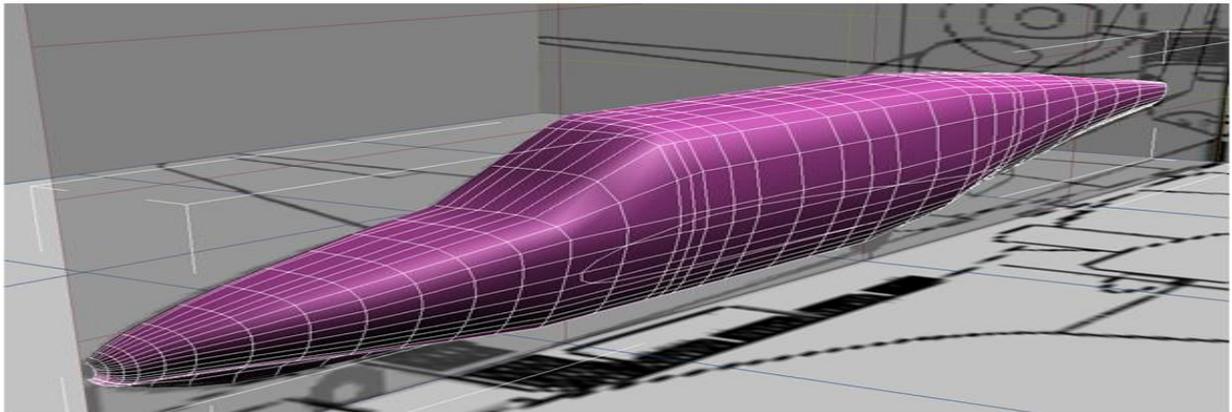

Fig-7. Result body extrusion after smoothing

Source: The author's original development, aspect ratio of figure is distorted

2.4. Modeling of a Tail Unit

Before selecting a number of polygons in the tail unit, it is required to review the aircraft projection from above (see Fig. 8, on the left). These polygons will be used as initial ones to make the vertical tail plane of future aircraft. The vertical plane consists of two main components, the leading and trailing edge and it is a rudder at the same time. The tail unit is simulated with use of polygonal extrusion method according to aircraft projections (Fig. 8). Cut the horizontal stabilizer mounting socket contour in the certain point of the tail unit plane with Cut tool (see Fig. 9). Then can be started sequential polygon extrusion, the result is shown in Fig. 9.
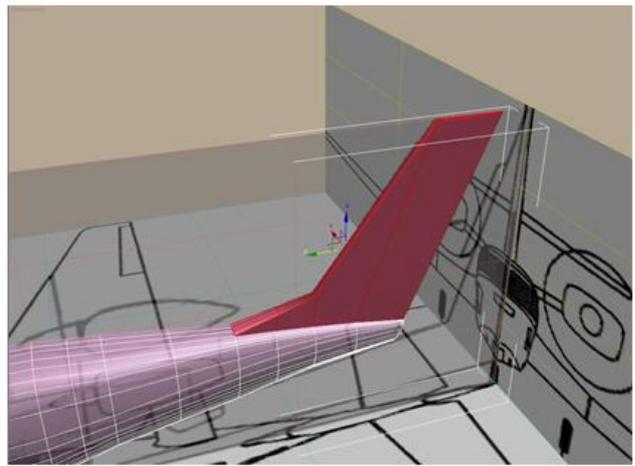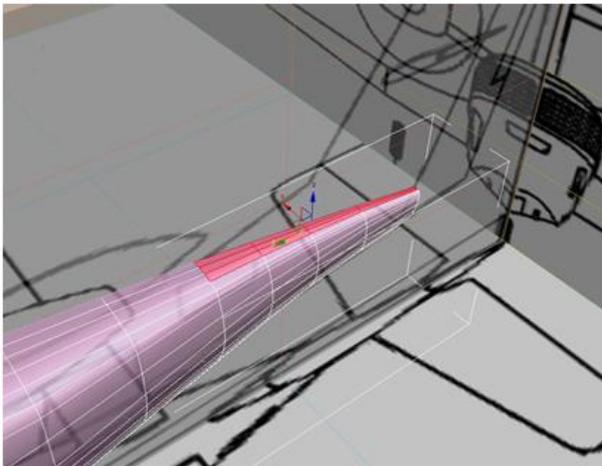

Fig-8. Sequential extrusion of tail unit
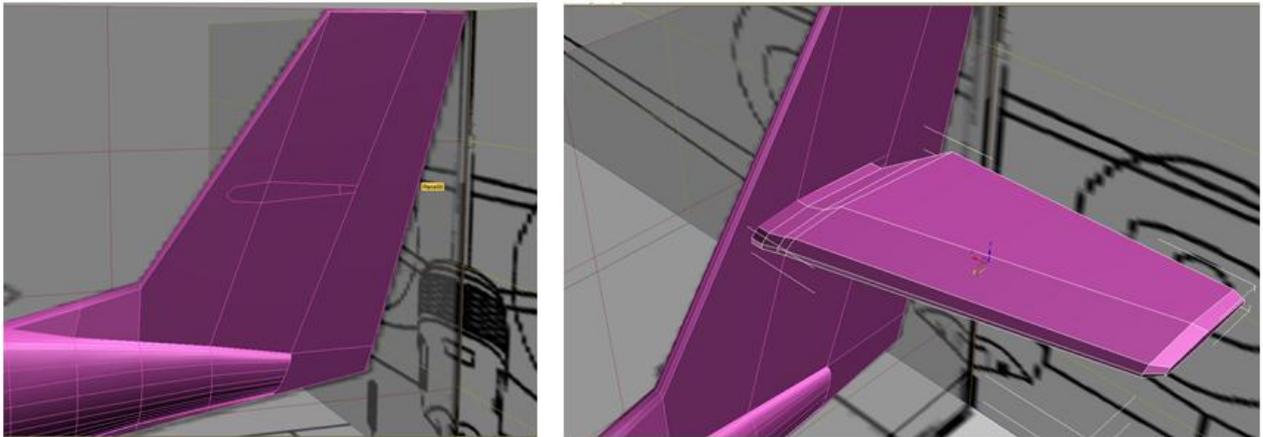
Source: The author's original development

Fig-9. Sequential extrusion of horizontal stabilizer

Source: The author's original development

When the tail unit has been simulated, can be changed over to the simulation of wing, another important part of future aircraft. The wing of the aircraft has a complex profile as it carries the aircraft while gliding, and acts as the screen, increasing the lift force at the time of taking-off from water surface.

2.5. Modeling of the Wing and Engine

The future wing is simulated from the body. The modeling procedure is similar to one used for modeling of the tail unit. Select a number of polygons on the lateral surface to replicate the contours of the wing mounting pad (Fig. 10). As a result will be get the polygons used for subsequent wing extrusion. Extrude the wing surface the same way, replicating the contour of the wing projection (see Fig. 11).
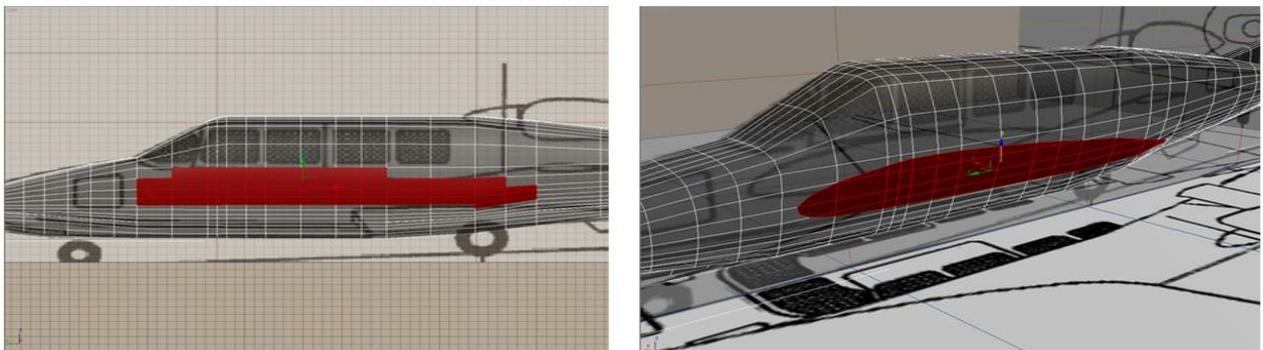

Fig-10. Consecutive extrusion of wing

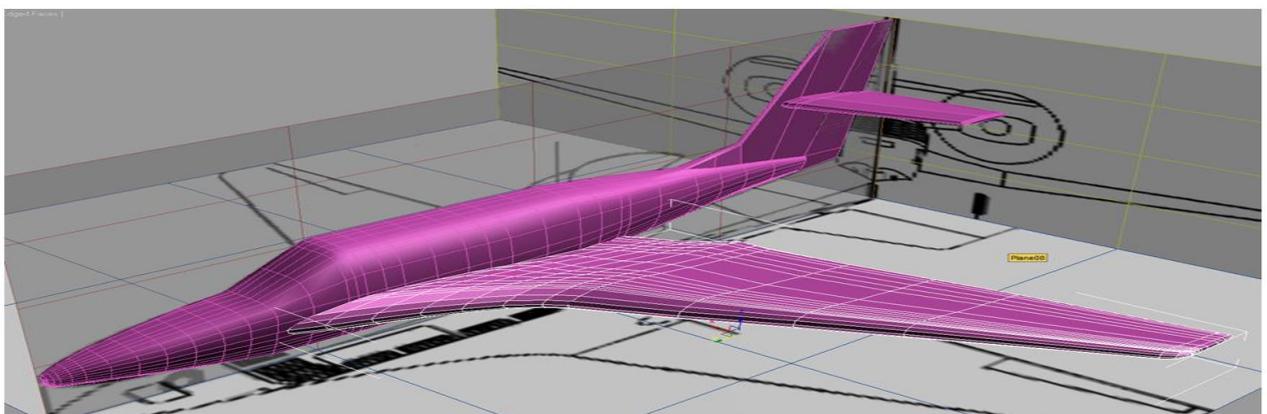**Source:** The author's original development

Fig-11. Aircraft body with tail unit and wing

Source: The author's original development, aspect ratio of figure is distorted

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All the remained aircraft components e.g. engine (Fig. 12), the rotor blades, and landing gear are created the same way.
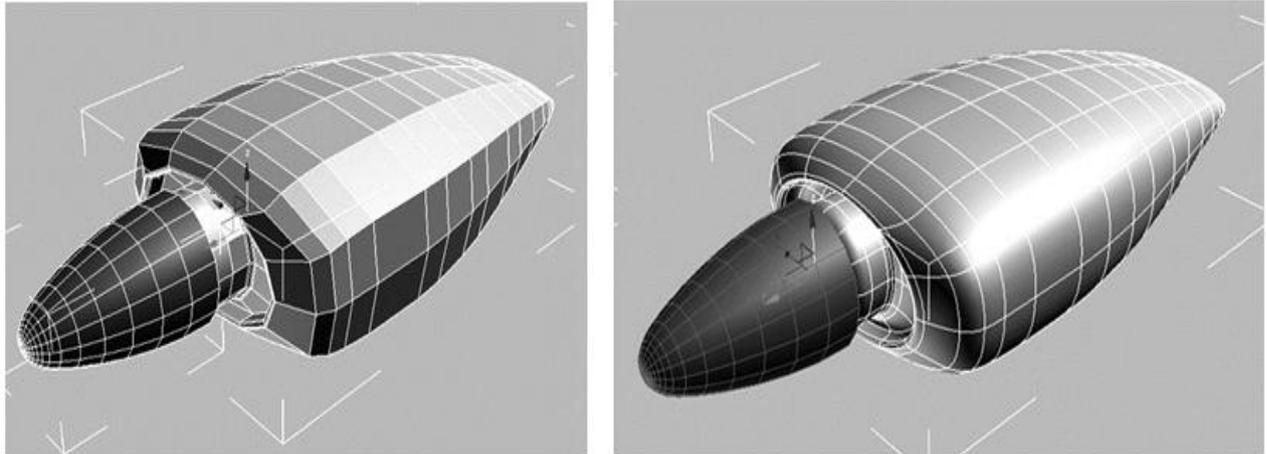

Fig-12. Creation of engine cover

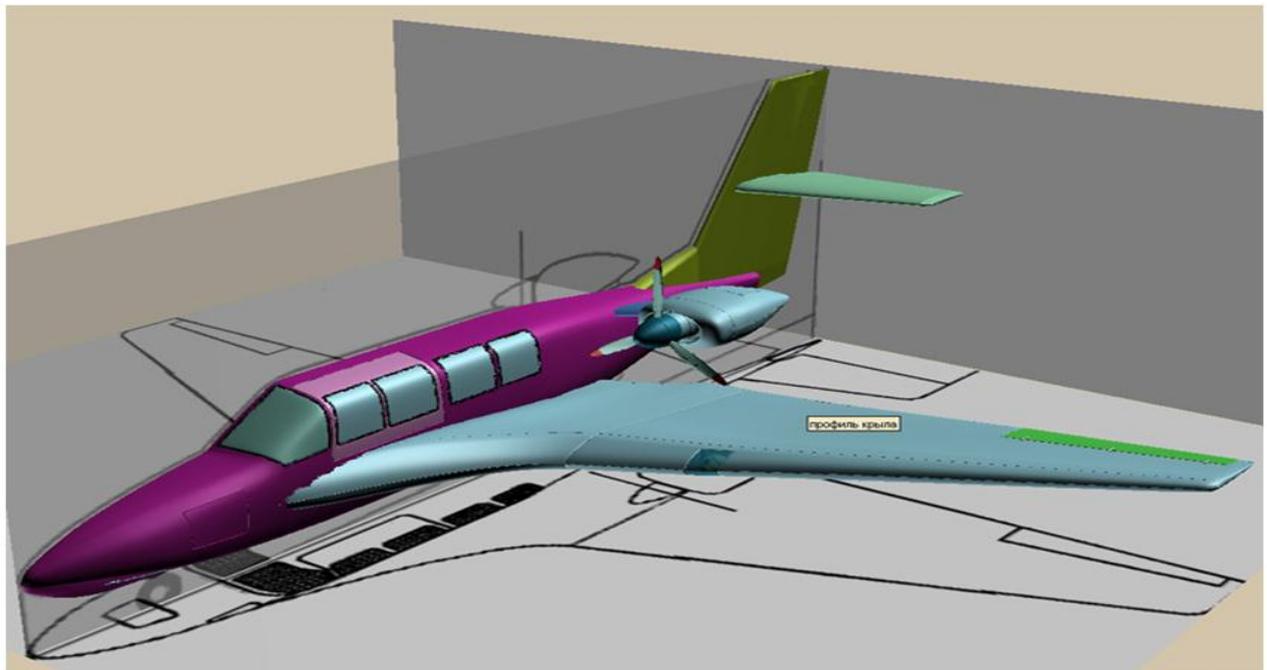**Source:** The author's original development, aspect ratio of figure is distorted

Fig-13. Connection of engine cover with the rotor blades

Source: The author's original development, aspect ratio of figure is distorted

2.6. Assembly of 3D-Model

At the following stage the model geometry is finished and the aircraft is assembled from its components: body with wing and tail unit, engine pylon (strut), engine cover and rotor (Fig. 13) [14]; [15]. Moreover, there are illumination lights on the wing and tail. Detailing of the body implies modeling of a wind screen and side windows. The wing together with rudder and horizontal stabilizer is to be detailed more precisely as well. In the end of modeling stage, need to reflect the half of the plane relative to the longitudinal axis (Fig. 14).

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Fig-14. Final assembly of Be-103 model

Source: The author's original development, aspect ratio of figure is distorted

3. SHADING OF 3D-MODEL

To get real photographic images in graphic-oriented system 3ds Max, the correct selection of materials and customization of its main properties are to be the depending ones. The V-Ray external rendering unit will be used for rendering, and it is stipulate the use of materials of VRayMtl-type library. The key parameter of material is the main color of it (diffuse color), the reflection properties are to be specified as well.
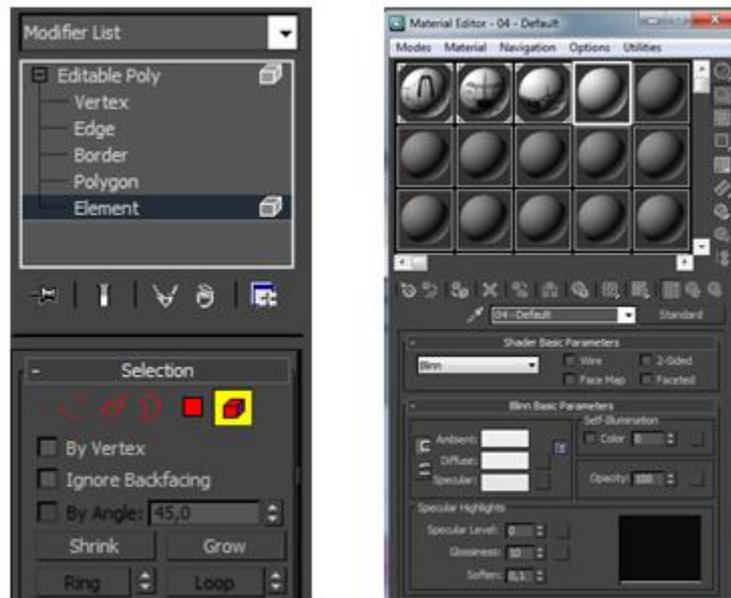

Fig-15. Materials assignment on the Element sub-level

Source: The author's original development

Materials to be assigned for different body parts at the Element sublevel of Editable Poly object (Fig. 15, on the left). Elements are selected one-by-one and assigned the previously made and adjusted materials with Editor Material tool (Fig. 15, on the right).

4. RENDERING OF 3D-MODEL

Lighting is important process of any 3D-scene that takes quite a lot of time. Commonly two types of lighting are used for this purpose – natural and artificial lightning. The graphic-oriented system 3ds Max has standard

rendering modules, but their capabilities do not provide the real photographic image. V-Ray module provides the better image. Sources imitating indirect lighting are used in the scene.

In a scene the sources imitating indirect lighting are established. In this mode the objects are illuminated by light what is diffusely-reflected from other objects, direct light from the direct light source does not fall on the object. Respective light sources were further applied to the scene and adjusted. See Fig. 16 for preliminary rendering of the aircraft 3D-model. See Fig. 17a and 17b for realistic rendering of Be-103 shaded model.

Fig-16. Preliminary rendering of Be-103 3D model

Source: The author's original development

Fig-17. Rendering of Be-103 shaded model

Source: The author's original development

5. CONCLUSION

Aspects of Be-103 amphibious aircraft 3D computation modeling were reviewed herein. An amphibious aircraft has essential advantages when using in extended coastal water areas, internal reservoirs. No doubt that advanced design and modeling of amphibious aircrafts, is an actual target in the development of hydro aviation.

In our case state-of-the-art graphic-oriented systems of 3D computation modeling were used for modeling. Choice of specific modeling method and respective instruments is mainly dependant on designer's preferences. Resuming the performed developments, we may note that the rendering scenes of Be-103 amphibious aircraft 3D modeling are considerably realistic and they provide rendering of object designed.

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