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Ship Hull Equipment Smart Modelling in 3DExperience

Abstract

In today's highly competitive industry, product development and manufacturing processes are becoming increasingly complex while the environment in which engineers work has changed. The development and advancement of digital collaboration software that integrates design, development and product lifecycle management is increasingly prevalent in shipbuilding. Namely, the high degree of integration of the ship structure design process with information related to the construction and equipment of the ship is directly related to the level of competitiveness of the shipbuilding project company or shipyard. The need for faster design and quick and accurate control of product quality in the early stages of ship design has encouraged the development and implementation of the latest generation of collaborative software, which has powerful capabilities for managing and improving the process of ship design, construction and exploitation. This paper will describe a "smart" modelling technique based on parametric modelling, the application of user-defined feature (UDF) functionality, the definition of Component family and relevant coding for selected elements of ship equipment in the modern shipbuilding, Industry 4.0 ready, platform 3D EXPERIENCE, to increase efficiency and quality when modelling repetitive elements of ship hull equipment.

Keywords: shipbuilding, 3D Experience, smart modelling, ship outfitting, Industry 4.0

1. Introduction

Smart modelling could be described as the process that uses intelligent and automated modelling tools to create 3D models with precision, accuracy, and efficiency. Such tools often allow for the creation of parametric models that can be easily modified and updated when necessary [1]. For a CAD model, "smart" means that it fulfils its

intended function, which naturally varies from component to component and can change over the lifecycle. Each company should establish uniform methods for using and recurring design tasks while modelling. The methods are a more recent feature and are not yet overrepresented, i.e., they are not entirely accepted and intended to be used as much as possible.

The shipbuilding industry has always been at the forefront of innovation and technological prosperity. With the emergence of digital technologies within the Industry 4.0 concept, shipbuilding has become even more efficient and accurate [2]. Smart modelling in shipbuilding is associated with using advanced functions, tools, and techniques to design and optimise various structural elements of shipbuilding and craft equipment. Smart modelling in shipbuilding offers many benefits, such as improved accuracy and efficiency in design, improved simulation capabilities, better cooperation and communication, and increased sustainability of facilities during exploitation. Most smart modelling functions are within a single 3D modelling platform, such as Industry 4.0 ready, Dassault Systemes 3D Experience [3]. There, choosing different applications allows users to use a particular function or activate multiple functions found in individual applications' menus. The use of advanced smart modelling features also enables the identification of design problems before construction starts, which can reduce the risk of costly design errors and delays [4]. Also, an essential item is greater certainty that ships will be constructed in accordance with the agreed specifications.

In addition to these advantages, smart modelling in shipbuilding offers several practical advantages. Smart modelling in shipbuilding promotes sustainability, optimises energy consumption, and reduces negative environmental impacts, which today represent a very important moral obligation for industry [2]. By using streamlined materials to construct structural elements and equipment, we also positively affect the environment. Smart modelling can also improve safety by identifying potential hazards and risks. In this context, some tools can be used to simulate different scenarios and test different designs, helping to optimise the ship's performance, thereby reducing the risk of accidents and improving the safety of crew and passengers.

2. "Smart" modelling

The purpose and objective of using smart modelling lies in the possibility of applying a large number of different functions that can greatly help develop larger and recurring projects. A classic example is the use of associatively linked blank and finished part geometries for cast parts, making it possible to prepare the blanks for production and, to a certain extent, to update them at the touch of a button in the event of subsequent changes to the finished part. This works particularly well if the smart product model is built so that the blank geometry is contained in the finished part geometry and can, therefore, be extracted without additional effort. Choosing different applications allows users to use a particular function or activate multiple functions in

individual application menus. Using advanced smart modelling features also identifies design problems before construction starts.

The main advantages of smart modelling are [4]:

- ◇ Speed
- ◇ Automation of repeating works
- ◇ Flexibility
- ◇ Relatively easy change of the whole model by changing the selected and defined parameters
- ◇ Saving of time and money
- ◇ Increase in quality

The basis of this paper is smart modelling functions, which will be used and presented. All functions offered exclusively by 3D Experience are used in this paper. 3D Experience is a cloud-based software platform created by Dassault Systèmes. It offers a complete set of tools and services for product design, engineering, simulation and project leadership. Furthermore, it enables cooperation between teams from different fields, such as mechanical engineering, electrical engineering, shipbuilding, etc. The popularity of 3D Experience lies in its ability to support the entire product development process. It also offers a unique data model that enables teams to work on the same real-time projects with real support. The platform supports improved simulation possibilities and offers a large number of simulation tools, such as structural analysis and fluid dynamics. These tools enable engineers to simulate the behaviour of their products on different occasions and to optimise their design appropriately, [5].

3. “Smart” modelling functions

3.1. Parametric modelling

Parametric modelling is a technique used in CAD design and production. This technique enables engineers to create 3D models that, without fixed dimensions, have the ability to easily and efficiently modify shapes based on specific parameters or regulations. Modelling using parameters is based on adding specific values to model sketches. This means drawing and dimensioning the sketch first and determining the parameters afterwards. Within Engineering Rules Capture, Parameter Explorer can be activated to determine the type of each parameter. Parameters can be of different types, such as length, string, integer, body, plane, etc. Parameter manipulation is done by replacing the value in the dropdown menu. Designers can build a model with a set of easily modifiable parameters to meet changing design requirements. For example, if a design needs to be modified to fit a specific size or shape, the designer can easily adjust the model’s parameters to reflect the new specifications. This shows the level of flexibility allowed by parameter application.

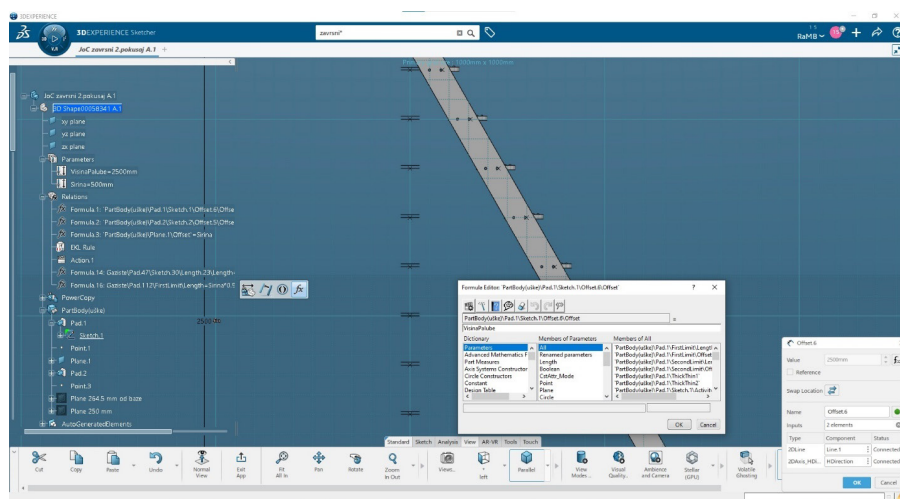


Figure 1. Display of activated parameterisation in 3D Experience

The use of parameters greatly reduces the occurrence of design errors and inconsistencies. The model is based on specific rules and parameters so that the design can be assessed for consistency and accuracy before finalisation. This reduces the likelihood of costly design errors and subsequent rework. In addition to the continuous development of CAD/CAM software, parametric modelling will continue to be an important tool for designers and engineers.

3.2. User-defined features

The user-defined feature (UDF) represents an advantageous and sophisticated way of creating model elements within a single workspace. UDF is user-defined data that can be saved and used multiple times in different parts of the design. The UDF usage process starts by entering data in the “User Feature Definition” pop-up window. In that window, an element intended for multiplication can be entered. This may include sketches, surfaces and 3D models. Also, input data may include parameters such as dimensions, angles and positions, as well as mathematical formulas. UDF automatically determines the input parameters required to create this element in another position by selecting the desired element. The finalisation of input data follows the activation of the function. Activation is performed by selecting the “Instantiate” option and then selecting positions. The UDF’s main advantage is its very high level of modelling automation that uses repeating elements. In practice, UDF is mainly used as a feature that allows models to be added to multiple design parts. In this situation, the UDF is created within the model or used through the catalogue to be instantiated repeatedly if necessary. By storing UDF-s in catalogues, designers can ensure that everyone

involved in the design process uses the same feature or tool. This reduces the risk of miscommunication and errors and ensures design consistency and accuracy. Another advantage of the UDF is that it can be adapted to meet specific design requirements. This is particularly true when modelling a specific part with uniform requirements or specifications. The UDF may be modified to meet specific design requirements without recreating the entire feature from the beginning. UDF can also be used to improve the efficiency of the production process. Using UDF, engineers can quickly and efficiently build complex models, saving time and reducing errors.

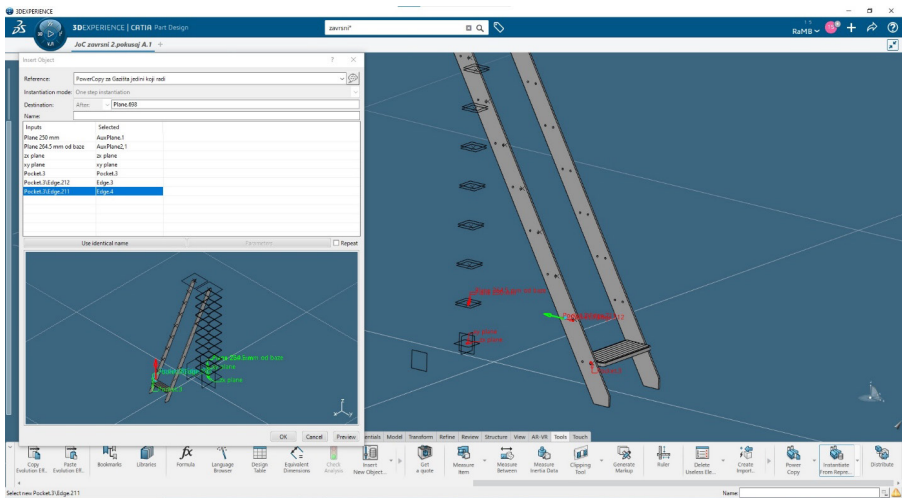


Figure 2. UDF Pop-up window in 3D Experience

3.3. Component family

A component family (group of components) is a function that creates a group of similar parts or designs that share common characteristics or features. Groups of components have a very important task: simplify the design process and improve efficiency. This function enables engineers to use existing elements and elements generated using input data from tables or handwritten dimensions. The application that allows users to use this functionality is called “Component Family Definition”. The essential feature of this function is the ability to connect the model to an Excel spreadsheet. The Excel spreadsheet contains the desired parameter values that are selected separately in each column of the spreadsheet. The dimensions of parameters in the 3D software and the spreadsheet are aligned with symbols representing the same measures. Selecting appropriate measurement units and the parameters’ nomenclature is essential. Any deviation in the terminology or choosing inappropriate units will result in an error or inability to make a model. After connecting the spreadsheet and the application, the “Test and Resolve Family items” tool checks each dimension entered

from the table and the functionality of the individual model that should be generated. At the end of the analysis, next to the element name, there will be a green circle if everything is OK or a red circle if we have an error in the model.

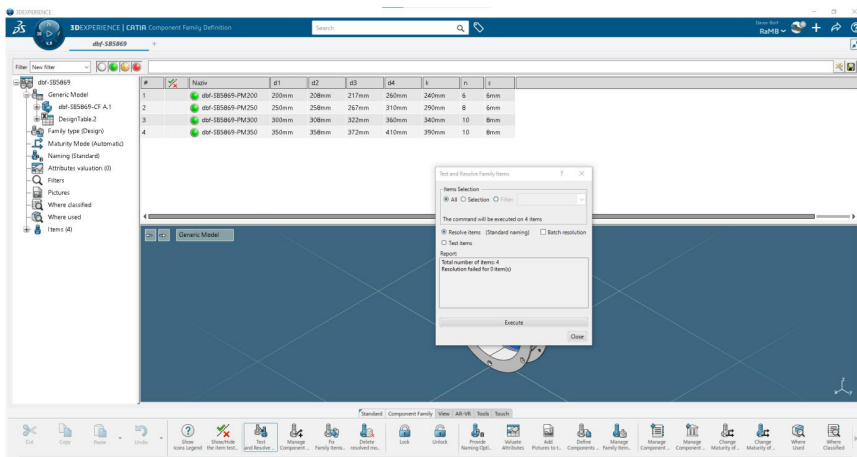


Figure 3. Component Family Interface in 3D Experience [2]

Once spreadsheet values and model dimensions are matched, a group of new elements will be created. The number of models this function can generate is not limited by number or type. Most often, the elements are stored in an individual catalogue, allowing these models to be invoked in any future project. Due to this possibility, the economic benefit of this function can be seen, as well as the potential of shortening modelling time.

4. Applicable techniques for real-time industry tasks

The increasingly demanding tasks of industry require the use of advanced functions, which will be presented in this paper as an example of staircase modelling. The model will not have fixed dimensions of height and distance between side sheets, allowing for greater flexibility when testing advanced modelling functions. Depending on the height and width of steps, the layout and position of the tread, the position of the ears and the length of the tread ribs will change. By using advanced functions within 3D Experience, it will be possible to accelerate the modelling process, which is a crucial factor in today's industry.

The stair lugs are the first item of this paper that will be modelled. The dimensions of the lines and the radius of the circle are determined. At the end of dimensioning, all lines should be green, indicating that everything is in geometric harmony. At the centre point of the hole circle, a plane is generated perpendicular to the plane in which the padeye is located.

After creating a sketch of the lug and plane, the “fall” function creates a 3D object representing the physical padeye model. The second padeye will be placed 500 mm away.

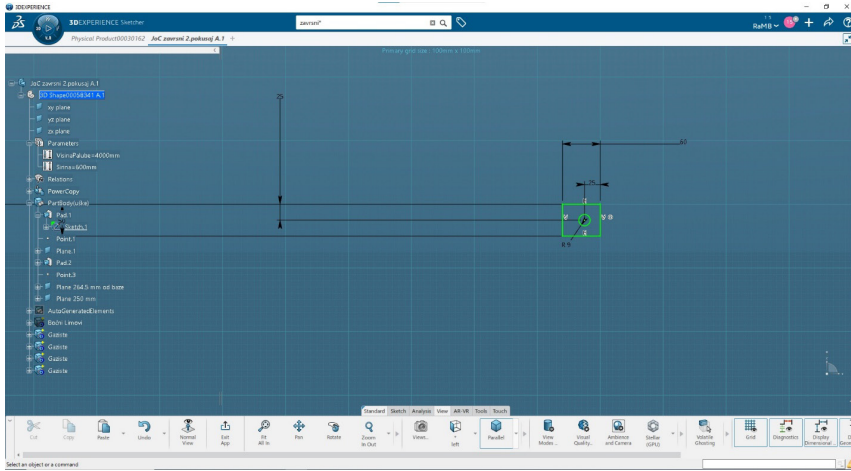


Figure 4. Creating the stair lug using the sketching application

Next, side plates that connect fixed stair lugs to the inner edges of the padeyes have been modelled. Diagonal lines are defined by a slope angle of 60° , not by the slopes' length. The top and bottom sides of the side plates have fixed lengths, but height parameters determine their position. The distance between side plates will also be determined using parameters activating the Engineering rules capture feature.

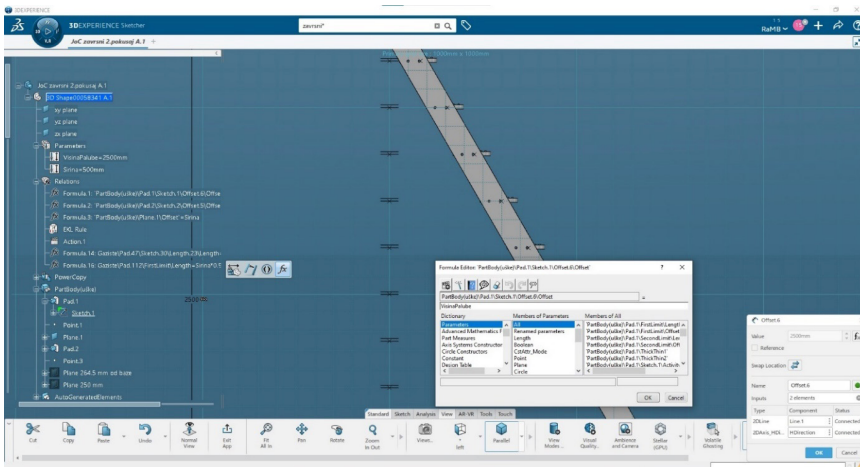


Figure 5. Parameters menu

After entering the parameters, another side sheet has to be modelled. It is created using the PowerCopy function, which multiplies the part of a model to a specified location.

Holes in the staircase allow for a fixed connection of stairs and side plates. They are modelled using the Action function. Action is based on user-written code using engineering knowledge language (EKL) developed by Dassault Systemes. This code is based on creating geometrical elements such as dots, planes, and circles as construction geometry and a hole in a side plate as the final result. To activate "Action", the user must open a staircase model in the Engineering Rules Capture app.

All input parameters shall be entered as explained by the code upon activating the Action function; the type of the input parameters shall be according to the EKL code designation to avoid any errors.

The holes are generated using a simple counter, creating the planes and points relative to the general height of the stairs. These points and planes have only a vertical variable value, while horizontal is determined using a simple expression. The points shall be auto-generated in each centre of the hole using the circle. These points will be pitched along the slope, and the formula will define the position of the x-axis:

$$x = \frac{(y-b)}{a} \#(1) \quad (1)$$

Each iteration will create a new point at a new height and position. After entering the code for the points, it is also necessary to define the circle's functions based on the position of those points. In particular, circles are created for the left and right perforations. Each circle has input parameters defining the circle's centre point, the plane in which it is formed, the circle's radius, the "offset", and the degree the circle covers. A new variable is added ($xRad1$, $xRad2$) and obtained by adding or subtracting a given value from the value of point x, [3].


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ime = "AuxPlane." + ToString(i)
ime2 = "AuxPlane2." + ToString(i)
me = "Krug." + ToString(i)+ToString(j)
Ivanje pložaja točki i ravnina samo za z os (visina)
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point(0mm,0mm,i*250mm)//pozicioniramo taj element
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za znamenku iza . Iiot)

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Figure 6. Code written in EKL programming language

The initial sketch is placed on a plane at a height of 250 mm. It is important to emphasise that the width of the step must be linked to the parameter of the width of the stairs. The step is modelled first by creating an outer sheet metal shell of the step and then gradually adding the step cover and ribs.

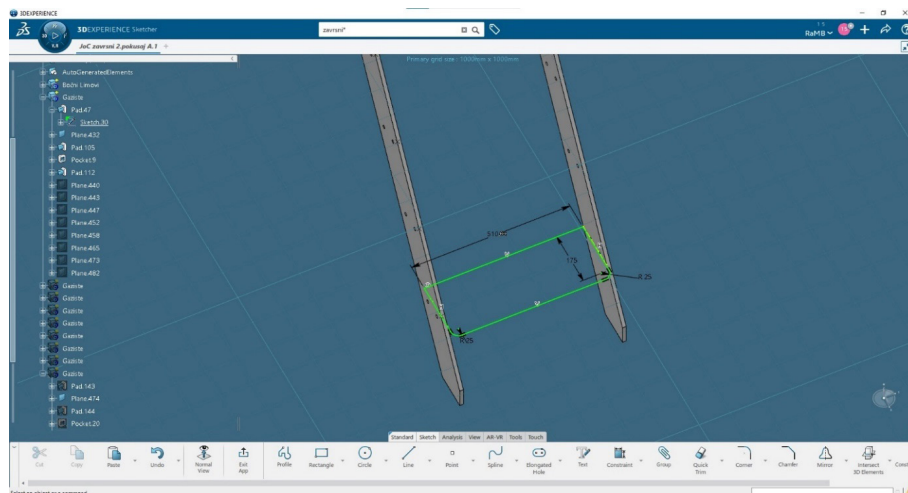


Figure 7. Outer sheet metal sketch

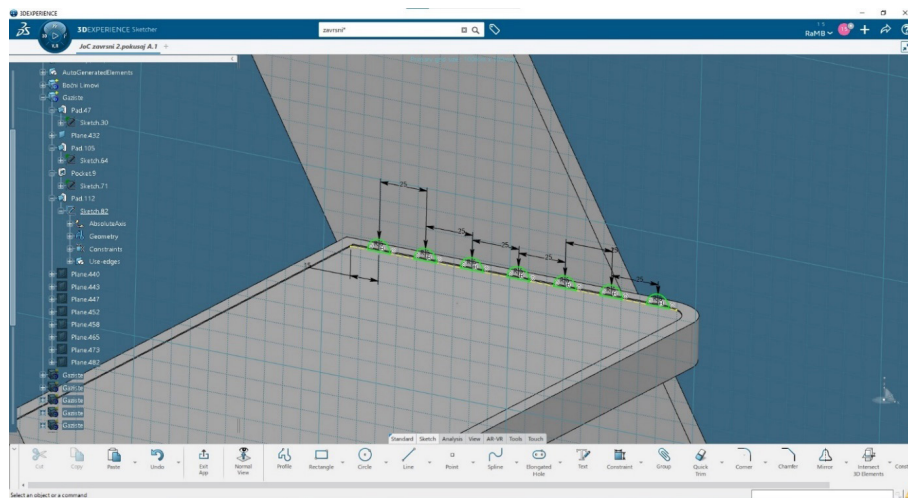


Figure 8. Sketch of stair ribs

The step model must also be placed on other heights in their designated positions. It is done using the command “Instantiate from Representation”.

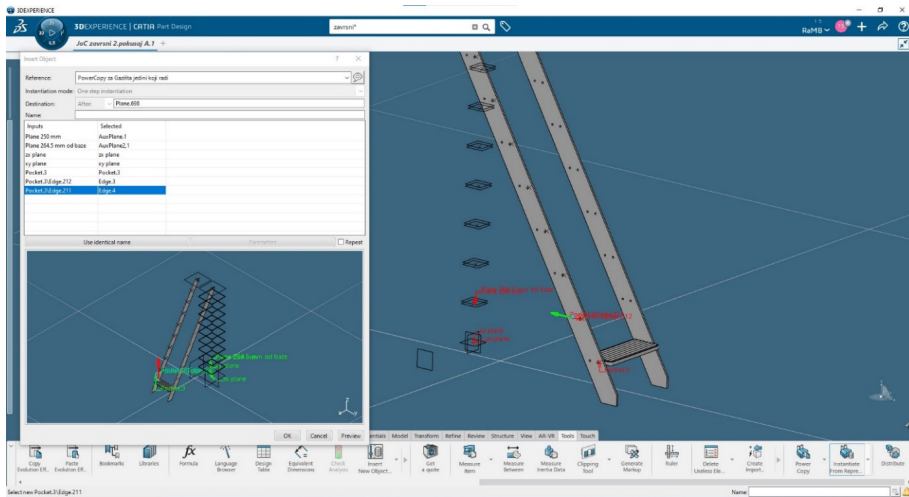


Figure 9. Instantiate from Representation menu

A window is opened by choosing a model in which input data to generate the new step can be selected. By pressing the name or the desired element, information about the plane of new step placement can be added. Additionally, the user can select the plane of the cover, the zx and the xy planes attached to the tread ribs, and finally, select the referent edges for creating the holes on the tstep side sheet metal.

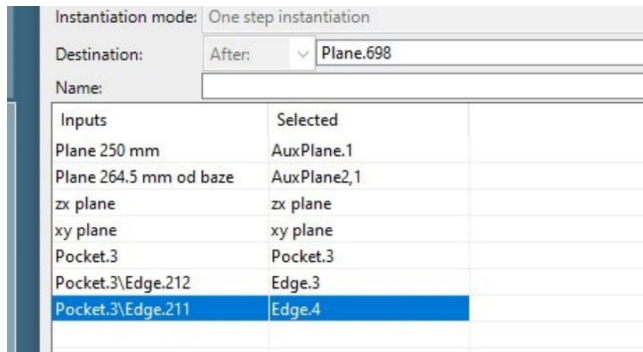


Figure 10. Input data

By completing the generation of all steps placed in the designated positions, we create two rectangular surfaces that determine the position of the steps in the working space.

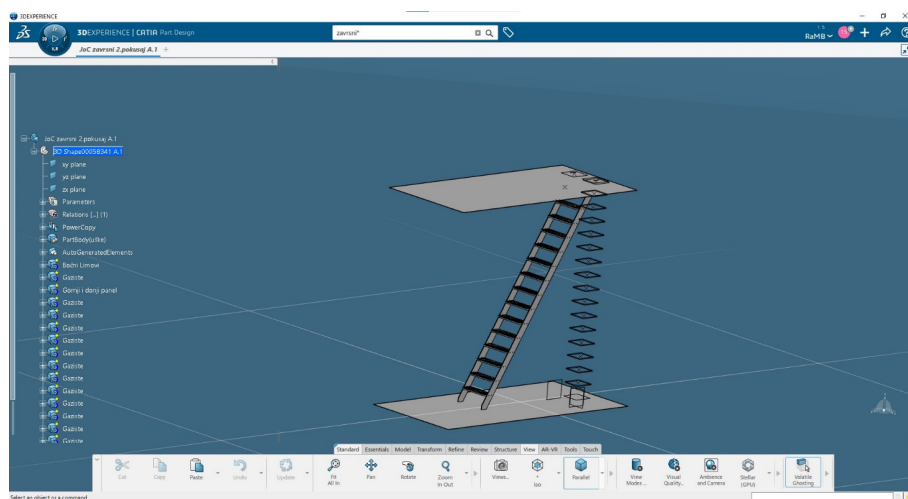


Figure 11. 3D model end layout

5. Conclusion

The presented case gives us insight into the benefits of advanced functions in 3D modelling. Through the process of modelling itself, the benefits of advanced functions in modelling are observed, such as:

- ◇ Reduction of modelling costs
- ◇ Less time to perform a project task
- ◇ The software enables higher product quality at all stages of the production of a ship or other construction elements
- ◇ The possibility of accomplishing more work in a shorter period
- ◇ Flexibility
- ◇ Automatisation of repeating tasks

This shows that smart modelling functions are essential in modern-day 3D CAD modelling. However, it also highlights that development requires excellent communication among all industry participants, i.e., constant and thorough research in various fields of technical sciences. Engineers and designers can use advanced techniques to learn skills from other technology fields. As a logical continuation of this project and research, a more profound use of different programming languages is required, and an even greater degree of automation is achieved. It will also be beneficial to include artificial Intelligence in this story. Due to the increasing use of AI in industry, AI is inevitably imposed as a modern and practical solution for this problem. Implementing such an option by the designers would enable an even faster and better

solution to the problem of automation in modelling. This applies in particular to self-recognition attributes, i.e., variables that would be identified as bench and changed as necessary, which are planned to be explored more sufficiently in future research.

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