METHODOLOGY FOR EFFICIENT APPLICATION OF 3D SHIP MODELLING SOFTWARE

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SUMMARY

Most of today’s Naval Architecture and Ocean Engineering University Departments prepare students with much theoretical knowledge. However, students will need to develop more practical skills in 3D modelling than what is presently provided. Since many shipyards are subcontracting the design documentation out of yard to exclusively design companies, more and more students upon graduation are finding jobs in small and medium enterprise companies (SMEs) that prepare detailed production documentation using advanced 3D modelling software. Thus, it has become normal for many design engineers to work locally without moving to a distant country since the internet has enabled efficient communication between shipyards and design houses. However, the need for engineers with practical 3D modelling skills is growing, and Universities need to meet this ever growing demand. Therefore, the development of a methodology whereupon students can receive the practical skills in 3D modelling during University studies through cooperation with SMEs would be useful. In this paper, an innovative approach to bridging the 3D modelling gap is explained. A case study at an actual University Naval Architecture and Ocean Engineering Department in cooperation with an SME describes how students are receiving hands on experience. Likewise, a practical demonstration in designing a foundations for ship equipment is described in a succinct and clear manner. The theoretical knowledge of understanding how to read classification drawings is explained as is the practical 3D modelling application. Nupas Cadmatic 3D modelling software is used in the case study.

NOMENCLATURE

SME Small and medium enterprise
3D Three dimensional
SFI Ship classification standards

1. INTRODUCTION

The importance of Naval Architecture/Marine Engineering University programs cannot be understated. Whereas it is possible for students from other Engineering programs to eventually gain experience necessary to work on ship design and in shipyards, Naval Architecture/Marine Engineering programs still produce most of the naval architects and marine engineers in the worldwide industry today.

The case is that even though the shipbuilding industry in Europe has declined during the past few decades, the Naval Architecture/Marine Engineering programs continue to attract and produce engineers employable by both local and international naval and maritime companies. The reason why is due to the advent and increase in computer 3D modelling of ship structures, and equipment. Up to 50 naval architecture/marine engineering small and medium enterprises (SMEs) exist in the city of Rijeka as a result of meeting the need for international maritime customers. These include shipyards such as Meyer Werft, Neptun Werft and Meyer Turku, as well as many others.

The example given in this paper includes explaining how students can be influenced to learn what the maritime customer wants, whether that be a shipyard or a large international vessel design office. The need for this proactive approach arose as a result of the need to answer the needs of the local industry.

Whereas the University program teaches students scientific and engineering theory during the extensive course load, there has been a lack of formal and state of the art ship 3D modelling training. Once students graduate from either 3 year or 5 year programs, they realize that companies are using specific software with which they had little to no experience. The reason why is because of the budget limitations to purchasing the plethora of software available on the market.

At the same time these SMEs approach the students as well as 3D modelling companies such as Nupas-Cadmatic [4] and FORAN. Whereas, it is impossible to spend extensive time in training students to use all of the 3D ship modelling software on the market, it is possible to immerse students to use software as it is made available due to partnership agreements between SMEs, the University and software companies.

In this paper an example of achievements in adapting avant garde 3D modelling through cooperation with industry in a novel way is the new paradigm in Naval Architecture/Marine Engineering education.

2. SHIPYARD DOCUMENTATION
The shipyard documentation and drawings are broken down into three basic groups. The Evans spiral is one typical illustration of this. [1], [2]. Likewise there are offshoots of this spiral as the one in Figure 1. The ship has more parts and requires the use of all engineering fields.

Figure 1: Ship design spiral [2]

The entire ship design can be broken up into three major milestones.
1) Contract design drawings
2) Classification Society design drawings
3) Production design drawings

The contract design documentation includes the following:
1) General Arrangement plan
2) Midship section drawing,
3) Capacity plan,
4) Preliminary trim and stability calculations,
5) Damaged stability calculations,
6) Heat and energy balance
7) Damaged stability

The vessel displacement, speed and general dimensions are defined prior to contract drawing as is the midship section. However, the plethora of other details which need to be approved by a classification society leads to the development of Classification society drawings which follows the Norwegian Ship Research Institute, formerly known as Skipsteknisk forskningsinstitutt or the popular abbreviation SFI system of classification [3]. All drawings are labelled in a uniform way. This means that there are 10 main group breakdowns along with the sub breakdowns. The ten main groups are:
1) Main group
2) Hull
3) Cargo handling equipment
4) Ships equipment
5) Equipment for crew and passengers
6) Main engine and related parts
7) Systems for parts of the main engine

8) Ship systems

Finally, the third and final set of documentation are the drawings used by shipyard production personnel. It is important to understand that the ship design process requires much time and resources, as well as engineers of all trades, not just naval architects and marine engineers, but also mechanical engineers, electrical/electronic engineers and even civil engineers, not to mention computer engineers.

All three design stages are necessary for a ship to be built. However, the production drawings define exactly how the interim products are to be made and outfitted. Likewise production drawings need to comply with the technological capabilities of each individual shipyard. For instance, whereas the contract design and classification society design for a specific ship design can be the same for different shipyards, the production design will always require some degree of changes to the drawings. This is due to the fact that the interim products differ from shipyard to shipyard and there are no two shipyards that are exactly the same [5]. This is due to differences in the shipyard layout and the production facilities. For instance, while the shipyards 3.Maj in Rijeka and Uljanik in Pula are managed under the Uljanik group, the production drawings are different in order to maximize the production facilities of each shipyard. One good example are the erection blocks. Since, 3.Maj shipyard in Rijeka has a larger gantry crane over the slipway (300 tons capacity), the erection blocks are much bigger than that in Pula. Therefore, the drawings need to reflect this.

3. STUDENT INDEPENDENT PROJECTS USING LATEST 3D MODELLING SOFTWARE

Students are required to undergo a few independent projects during the duration of their education. This is one opportunity for proactive students to opt to do a project related to 3D modelling in shipbuilding using some of the most modern ship design software on the market. The case that will be reviewed in this case study is an example of work performed by a student at a local Naval architecture/Marine engineering SME. The rest of this section are instructions on how to use Nupas Cadmatic software for defining equipment foundation modelling for ships.

Whereas, contract documentation and drawings do not require the development of a 3D model, the production drawings require the creation of very detailed and accurate 3D models. With the advent and improvement of 3D models, shipyard production is receiving better documentation with isometric as well as two-dimensional views in the various assembly phases. This enables more accurate planning of shipyard jobs. Likewise, the shipyard workers are more readily able to read the drawings without having to learn the archaic symbols that are used on traditional two-dimensional drawings.
3.1 FOUNDATIONS OF SHIP EQUIPMENT

The fifth year student in the Masters program had done an internship at a local SME. The specific design involved designing and modelling foundations for ship equipment. The prerequisites for designing any foundation are that the ship structure must be defined and modelled as well as the actual equipment. Only then is it possible to determine the exact characteristics of the foundation. Likewise there are certain rules and constraints which the designer must abide by. For instance, it is forbidden to weld anything to the edges of structural stiffeners, girders, and openings. The foundations are always manually welded to the hull structure where permitted according to the rules. The constraints that designers must pay attention to are:

1) The dimensions and mass of the equipment
2) The exact position
3) Whether the equipment will touch other equipment or pipes
4) Choosing the proper dimensions of stiffeners or steel plates
5) How to make the connection to the hull structure

In order to make the above listed design decisions, it is necessary to constantly check drawings and specifications. For instance drawings of the equipment, and the preliminary drawings of equipment locations.

3.2 CASE STUDY OF FOUNDATION DESIGN MODELLING

The foundation that the student needed to design was for a starting air tank in the engine room. The starting air tank is used to initially get the pistons of the main diesel engine moving in order to then achieve the necessary compression which is necessary to create internal combustion which then moves the pistons (See Figure 1).

First, the designer checks the dimensions and shape of the starting air tank, and then the mass. The greater the mass of the equipment, the greater the required strength of the stiffeners as well. Sometimes the mass of the equipment is not known, and it is necessary to estimate it based on the dimensions and the specific gravity of steel. Since the starting air tank is made of steel with considerable dimensions, it can be assumed that the mass is considerable as well (over 100 kg). Therefore the stiffeners will also have to be of greater dimension than usual. Likewise, it is necessary to choose stiffeners which are readily available at the shipyard.

The bulb stiffeners are inserted by using the “Insert” option of the Structural menu in Nupas-Cadmatic (See Figure 2).

Figure 2: Inserting stiffeners from the Structural menu

Once the profiles are placed in position, then it is necessary to define the exact type from a menu of choices as in Figure 3 below.

Figure 3: Menu of stiffener choices

After the profile type is chosen, then the stiffener is positioned by choosing the start and end positions as in Figure 4 below.

Figure 4: Position of the bulb stiffeners in three views (plan, side, and cross-section views)
When the coordinates are known for the position of the profiles, then they are manually entered by pressing the letter “C” as in Figure 5 below. A different method is by using the snap command (“E”) key. The condition is to find the exact same point in at least two views.

Once the final point is chosen, the direction of the profile stiffener is oriented by pressing the “Enter” key. A new profile stiffener is shown in the model (Figure 6).

The next step is to add a stiffener to the opposite side, which is necessary to act as a foundation. Since the profile stiffeners have identical dimensions, it is quicker to just copy and use the mirror command as can be seen in Figure 7 below.

A small space is left between the profile stiffeners of the foundation and the profile stiffeners attached to the hull structure. The reason is to allow space for a steel plate known as a doubler which allow a connection between profile stiffeners and also does not directly touch the hull structure. These steel plates are characteristically thicker than the profile stiffeners by 2mm. Therefore, it is necessary to use an 8mm thick doubler. The steel plates are inserted in a similar manner as profile stiffeners (See Figure 11) through choosing the type of steel plate and thickness (Figure 12).

While using the command, it is necessary to choose the proper surface the element will be mirrored upon. Using the “O” button from the keyboard to choose the profile stiffener. Afterwards the “Enter” key is pressed. Then it is necessary to choose the point where the mirroring will take place. It is possible to press the snap key “E” or the midpoint by pressing the “G” key. The midpoint is used and the situation is as in Figure 8. After the midpoint appears, the “Enter” key is pressed and the cursor positions itself in the middle as in Figure 9. Then, by clicking the mouse button the actual mirroring of the profile stiffener is executed and completed (Figure 10).

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Inserting steel plates also requires the choosing of a reference point which will be the origin of the steel plate. Only one point is chosen for modelling a steel plate. Then the menu for the shape of the steel plate is chosen as in Figure 12 below.

Upon clicking “OK” shown in Figure 14 above, the steel plate gets placed in position. The steel plate must be dimensioned so that it is large enough to satisfy a sound connection between the hull structural stiffener and the profile stiffener of the tank (See Figure 15).

There are various shape types as in Figure 13. However, for ships equipment it is normal to use a rounded rectangle. After clicking rounded rectangle then another menu opens up, where it is necessary to define the size of the steel plate dimensions (Figure 14).

It is necessary to repeat this for all four vertical tank support profile stiffeners. Since all four stiffener profiles are identical, it is possible to use the “Copy” command (Figure 16). The doubler to be copied is chosen by pressing the “O” key (Figure 17). Afterwards, an arrow appears and it is necessary to choose the direction of the copied doubler (Figure 18), upon which a new menu appears (Figure 19) where the number of elements to be copied are chosen as well as the distance. With a click of “OK”, the new doubler is successfully copied to the prescribed position (See Figure 20).
Next it is necessary to choose the tank from the database by selecting “File” and “Check Out” as in Figure 20 below. After the correct tank from the database is chosen, it is possible to use the “Move” in order to position the tank to the correct position.

The next command that is necessary to use is the “Move” command in order to move the tank to the optimal position in order not to change the positions of any pipes which need to be connected to the tank (Figure 22).

It is next necessary to attach horizontal profile stiffeners to the vertical profile stiffeners (Figure 23), upon which a horizontal steel plate is added on top by using the insert plate command (Figure 24). This is necessary in order to properly assemble the cylindrical tank to the foundation. The strength of the resulting foundation structure will satisfy classification society requirements.
Since the steel plate is not properly dimensioned, it is necessary to press the “Section” tab from the top menu and then update its exact size (Figure 25).

Using the right click of the mouse makes it possible to choose from an entire list of commands (Figure 26).

It is necessary to make sure there is enough space between the profile stiffeners and the steel plate in order to allow for accessible welding. Finally the completed foundation structure appears as in Figure 27 below.

4. CONCLUSIONS

In conclusion, it is very useful for students to be exposed to the latest ship design tools used by industry. Since University Naval Architecture/Marine Engineering programs have a core structure which cannot cover all the detailed software solutions due to constraints in time and resources, it is very practical to allow for student exchanges at the design houses where the advanced year students are able to get hands on experience while learning the avant garde tools of the trade. In this way, as soon as the students graduate, they have the necessary theoretical as well as the corresponding complementary practical skills to immediately get to working on real shipbuilding design projects.

5. REFERENCES


6. AUTHORS BIOGRAPHY

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