

Drilling Rigs Modelling Using AVEVA PDMS Software

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Abstract

This paper deals with the modelling of drilling rigs (a laboratory model) with hydrostatic actuating using PDMS software. The work is a part of the master's thesis obtained by collaboration between the authors [11]. The modelling constitutes a premiere in the context of designing drilling rigs, the software being focused on the construction of petrochemical facilities. The advantages of the use of the software and the achievement of the subject are highlighted. The work was made possible by the donation of 14 licenses of AVEVA PDMS Company under a cooperation program with the Petroleum-Gas University of Ploiesti, initiated in 2010.

Key words: *drilling rigs, plant design management system (PDMS).*

Introduction

In July 2010, the company AVEVA organized a training with the teaching staff of the Petroleum-Gas University of Ploiesti, in order to present the product Plant Design Management System PDMS. In that occasion were donated to the university 14 licenses v. 12.5 PDMS which can be used by students and teachers for training. In September, AVEVA organized a symposium in the Petroleum-Gas University of Ploiesti attended by oil companies and university teachers who had exchanged information about industrial applications realized with this software. Following these actions, at the former Department of Petroleum and Petrochemical Equipment were introduced the master courses *Computer Aided Design of Oilfield Equipment and Dynamic Equipment for Hydrocarbons Transportation* [13], features for using the software with applications. Currently in the context of the master's thesis a number of four students are using this software to treat some applications related to: completion of drilling facilities [11], modelling of waste water treatment system [12], modelling of a pipeline system, and achievement of a refinery pipe supports.

This paper concerns the modelling of drilling rigs (a laboratory model) with hydrostatic actuating into PDMS software. This application was preferred due the reduced number of elements comparative with an industrial drilling rig, which allowed its modelling during the time allocated to the achievement of the graduation project, but also addressing related issues such as: system analysis, determine the conditions of efforts on the structure, assembly plant.

The AVEVA **Plant Design Management System (PDMS)** software is a multidisciplinary three-dimensional modelling system, which allows detailed simulation of entire model of a plant

process, but can be extended to diverse industrial applications such as ships, drilling rigs, and mining installations. The software ensures a closest to reality representation of the factory's elements. The model can store a large quantity of information referring to the position, size, number of parts and geometric relationships between different parts of the model. The model becomes the only source of data for all sections and disciplines integrated into the project development. All information is kept in the databases, in which it can be extracted, as shown in figure 1, text reports, notes corresponding 2D drawings, isometric pipe and HVAC (heating, ventilation and air conditioning), interfaces related to analysis of efforts, and details about the products [1-10].

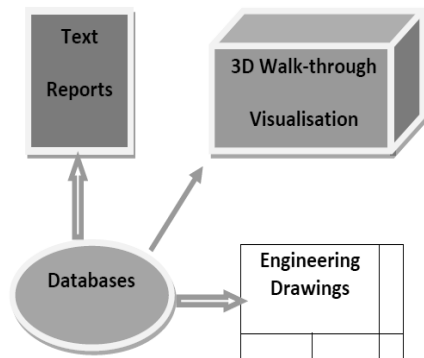


Fig. 1. PDMS Databases and its output channels (text reports, 3D representations, 2D drawings) [1]

PDMS contributes to the design quality by the following aspects [9]:

- ensures consistent and reliable component data;
- adheres to definable engineering specifications;
- ensures correct geometry and connectivity;
- avoid component interferences;
- the marks on the drawing and dimensions can be obtained directly from the database.

Structure of the Installations Modelled

The laboratory model of a drilling rig with hydrostatic actuating (fig. 2) is intended to reproduce a drive system using hydraulic cylinders, loads (drilling string) being simulated using a hydraulic cylinder with separate supply.

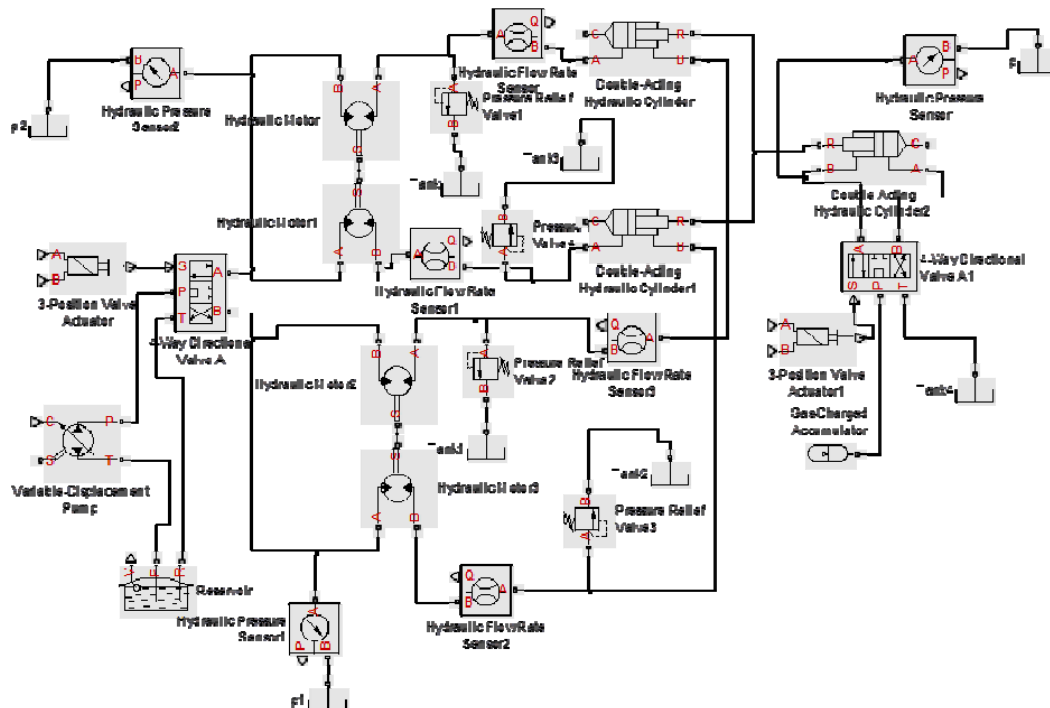


Fig. 2. Hydraulic scheme (partial) of the installations into Simhydraulics software

To synchronize the movement of cylinders hydrostatic motors, mounted on the supply and the discharge of cylinders, were used. The system includes: measuring instruments for flows and pressures; the security valve elements; the elements for distributing control; the sources of power; hydrostatic pump and an accumulator. Hydraulic cylinders are connected by a traverse, guided by a structure, modelled within the project.

Project Description

The concept of this project is to highlight the functions and capabilities of AVEVA PDMS software through laboratory model of drilling rigs. Items were created exactly in the same position as in the real laboratory model of the Petroleum-Gas University of Ploiesti: the Reactive Guidance Structure (RGS), the Mobile Platform (MPf = Traverse (T) + Hydraulics Cylinders (HC)), the Reactive Cylinder (RC), the Electric Motor (EM) connected to the Hydraulic Pump (HP), the Rotary Hydraulic Motor (RHM), the Tank (Ta), the distributor (D) and the rest of the necessary items not mentioned, but shown also in figure 3. After pressing F8, (in PDMS) figure 3 looks as shown in figure 4 (we see the Planes which define the elements). Figure 5 below shows a North View of the model in DRAFT module.

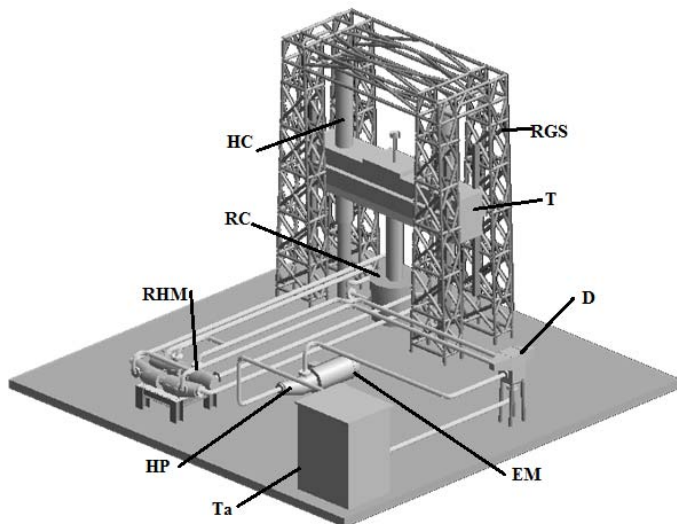


Fig. 3. Drilling rigs modelled into PDMS (Isometric view).

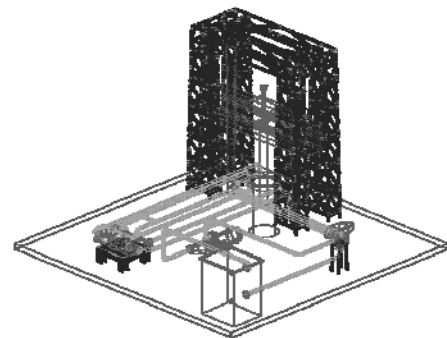


Fig. 4. Drilling rigs modelled into PDMS (isometric view after pressing F8).

In PDMS there are some administrative elements: SITE; ZONE, Structure (STRU); they exist to own framework (FRMW) elements, and allow the plant structure to be sub-divided for improving of modelling and reporting. Figure 6 gives an overview of the levels of the hierarchy within the Design module. Figure 7 shows how the PDMS database is structured in a logical hierarchy in the Design Explorer. All the elements are owned by other elements, with the exception of the WORLD.

The EQUI element must be positioned with respect to the “*wrt world*” (or other existing element) coordinate system. We have positioned the base as *East 0, North 0, Down 100 wrt World* (all dimensions are in mm). Next, we created the Box. The origin of the Box (in the very centre) is placed at the origin of the EQUI element, as previously defined. We entered the X Length as *10000*, the Y Length as *10000* and the Z Length as *200*. As the Equipment origin is currently set to *Down 100* with respect to the World, and the origin of a box is at its centre, a Z Length of *200* puts the top surface of the Box at *0* on the Z axis. We checked the position of the top of the Box by selecting Query > General... from the main menu and set the drop down

boxes to: Position, P3 (key point) and World. The result in the pane below should give a Position of *E 0 N 0 U 0*.

To create the tank, in the Equipment Zone, we created first another EQUI element and positioned it as *East 4000, South 4000, Up 800 wrt World*. Next, we created the first Box (Box1). The origin of the Box (in the very centre) is placed at the origin of the EQUI element, as previously defined. We entered the X Length as *1400*, the Y Length as *1200* and the Z Length as *1600*. The Z Length of the Box must be the double of the *Up* of the EQUI element to set the Box on the top of the base. Then we created the second Box (Box2) with the X Length as *1500*, the Y Length as *1300* and the Z Length as *40*. The origin of the Box (in the very centre) is placed at the origin of the EQUI element. The second Box will initially be placed at the origin of the EQUI, and so will be sitting in the middle of the first Box created, as shown in figure 8. Once the *Create* button has been clicked, additional modification options appear on the form, one of which allows the position of the primitive to be adjusted. By typing *800* into the *Up* box and pressing *Enter*, the second Box will be set on top of the first Box created, as shown in fig. 9.

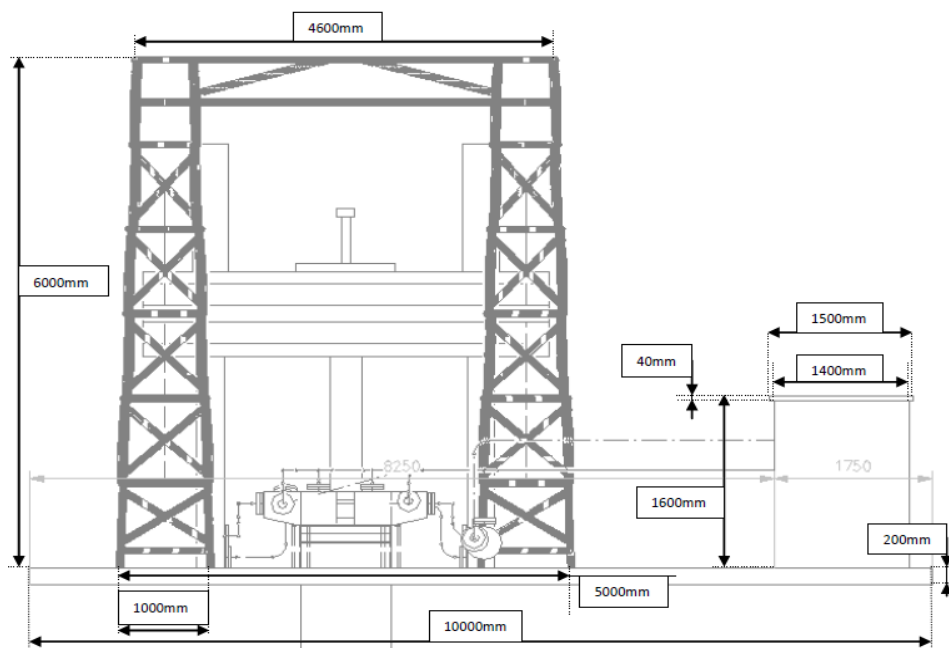


Fig.5. Draft (north view)

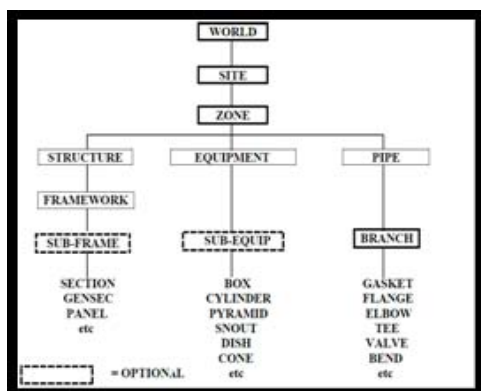


Fig.6. Diagram of the levels of the Design hierarchy [2]

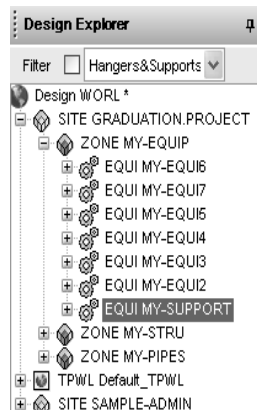


Fig.7. Database's hierarchy in the Design Explorer.

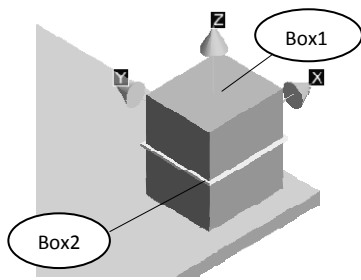


Fig. 8. Tank creation.

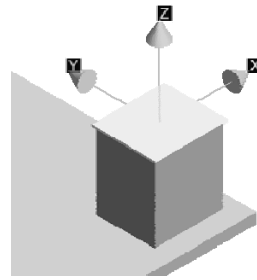


Fig. 9. Tank.

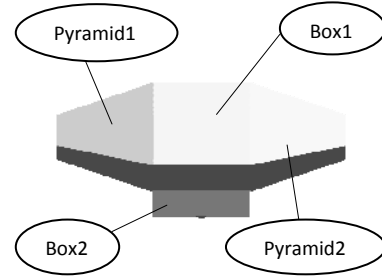


Fig.10. Distributor.

The distributor is created in another EQUI element. It is composed by two Boxes and two Pyramids. And its desired position is got by using the Model Editor, which can be used to position and rotate items in the PDMS database. Figure 10 above shows the distributor created within PDMS. A fourth EQUI element is created for the Electric motor and the Hydraulic pump. The Electric motor is selected as a Standard Electrical Component from the PDMS database. The Hydraulic Pump is built using the cylinder and snout primitives. Figure 12 is giving a view of Electrical Motor connected to Hydraulic Pump. To create the Rotary Hydraulic Motor, a new EQUI element was first created at the position as *West 1500, South 2500, Up 1012* (in which 1000 represents the Column height and 12 the thickness of Panel), wrt World to set it on the stand. Then using the Copy with Offset function, we copied the Hydraulic Pump and pasted it on the stand, in the Rotary hydraulic Motor's EQUI element; and then using the Copy Mirror function, we created the Rotary hydraulic Motor, presented in figures 13, 14 and 15. To create a copy by mirror, a mirror plan must be created at the middle distance between the object and the image to be created.



Fig. 11. Model Editor Icon.

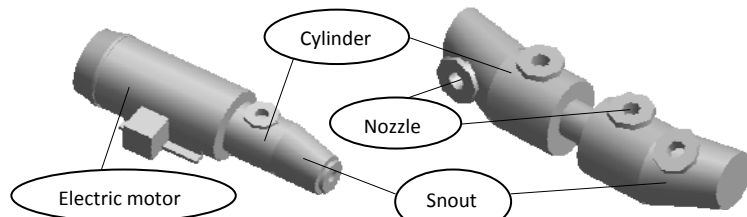


Fig. 12. Electrical Motor and Hydraulic Pump connected.

Fig. 13. Rotary Hydraulic Motor creation.

The Traverse is done by creating a 2D profile using the *Extrusion* function. Nozzles are significant to the Design because they provide the link between the Equipment (which owns them) and the Pipe (Branch) which is connected to each one. It may be helpful to think of a nozzle as being an Equipment attachment point.

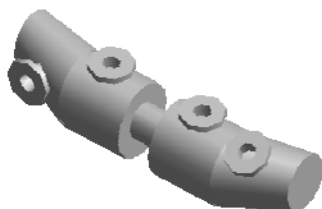


Fig. 14. Rotary hydraulic motor creation

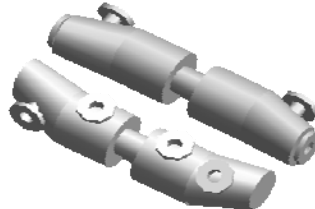


Fig. 15. Rotary hydraulic motor

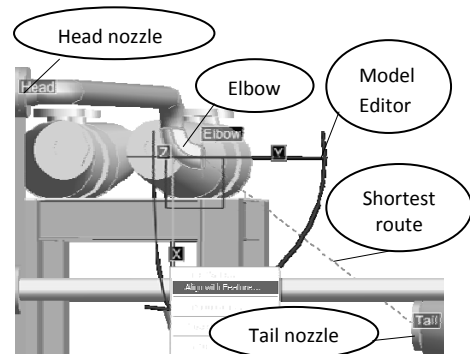


Fig. 16. Pipe being created.

Once the Nozzles are created (in the Equipment Zone), *Pipes* can now be created. To do this, a PIPE Zone must be created first under the Site. Then, clicking the *Pipe Creation Form* button from the *Pipework Toolbar* we loaded the *Create Pipe form* and set the *Pipe Specification* to A3B and the Bore to 100. Clicking the Apply button on the previous form automatically loads the *Modify Pipe form*. The form can also be accessed by selecting the *Pipe Modification* button from the *Pipework toolbar*. To set the start and end points for the pipe, first, the *Change* button under the *Head Connection* heading must be clicked. The form changes to allow a point to be selected. Clicking the *Pick* button; selecting the Nozzle desired to be at the head and then clicking *Connect* confirms the selection; then clicking the *Change* button under the *Tail Connection* heading, clicking the *Pick* button, selecting the Nozzle desired to be at the tail and clicking *Connect* confirms the selection. Then a dotted line (Branch) appears showing the shortest route between the two nozzles. Next, selecting the *Pipe Component Creation* button from the toolbar loads the *Component Creation form*.

To add a Flange and Gasket to the nozzle, the Branch must be selected in the Design Explorer. Then a *Weld Neck (WN) Flange* was created with the *Against Flow* button selected. We checked to make sure that *With Flow* and *Auto Create Adjacent* are selected at the bottom of the form. *With Flow* tells PDMS to create the components from the Head and work forward. Switching to *Against Flow* will set the component creation to start from the tail and work backwards. *Auto Create* automatically adds any essential components. In the case of a Flange, a Gasket will be placed in front of it. Clicking the *Connect* button creates the gasket and flange attached. Next we made sure that the Flange was the current element in the Design Explorer, and we created an Elbow (EL90). Using the Model Editor, we positioned the Elbow to line up with the tail nozzle, by right clicking on the X Axis handle and we selected the *Align with Feature...* function. Once *Align with Feature...* has been selected, we positioned the mouse over the centre of the tail nozzle to snap to the position, and clicked to confirm. A length of pipe is automatically created between the flange and the elbow. Next another Elbow must be created and rotate so that the *open end* faces the tail Nozzle as shown in figure 15 above. Then we repositioned it using the *Align with Feature...* function again to bring it in line with the tail Nozzle. While the *Through normal Point Feature* appears, one click needed to be made on the tail Nozzle to create the length of pipe from the elbow to the tail Nozzle. To add a Flange and Gasket to the tail nozzle, we selected the Branch in the Design Explorer and created a *Weld Neck (WN) Flange* with the *Against Flow* button selected. Figure 17 shows the pipe composed of two branches, with a Tee created in the first branch.

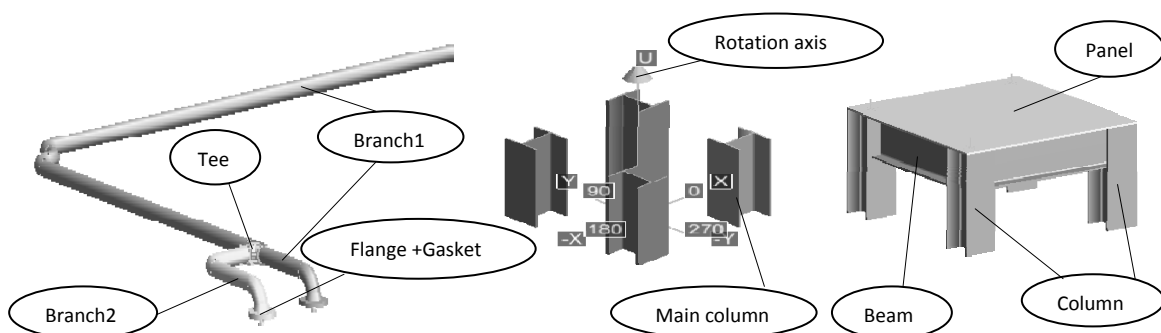


Fig. 17. Pipe (with two branches connected)

Fig. 18. Creating columns.

Fig. 19. Stand

Finally, we achieved the *Structures*. After the creation of structure Zone, we created the Stand Framework (FRMW) and the Reactive guidance structure FRMW. To create a Stand, we selected first from the *section specification* window: *British standard- Universal columns* and *Universal Beams*, and set the *justification* at *Neutral Axis (NA)*. We created the first column (main column) using the *Explicit Position button*, and using *Copy rotate* function we created the

three others columns (fig. 18). To create a copy by rotation within PDMS, we needed to define the number of copies, the rotation angle, and the rotation axis (parallel and in the centre of the $n+1$ columns) with its direction in *wrt world*. We proposed the formula for calculating the rotation angle: $\alpha = \frac{2\pi}{n+1}$, where n is the number of copies. The beam is created by clicking on

the top of one of the columns and selecting the top of an adjacent column, and then clicking the Accept button which appears automatically. The other three beams are created in the same way.

Figure 19 shows the stand with the panel already created. To create the Reactive guidance structure, *section specification* must be set first to *British standard- Circ Hollow Sections*, and the *justification* to *NA (Neutral Axis)*. *Element* and *Any* must be selected from the pull downs in the *Positioning Control Toolbar*. We created four columns by using the *Explicit Position button*. To create Beams, the pull downs in the *Positioning Control Toolbar* must be changed first to *Element* and *Snap*. Then by clicking on one of the columns and selecting an adjacent column, and then clicking the Accept button, the beam is created automatically with two nodes connecting it to the columns. The other beams are created in the same way. After the creating of Bracings, the first part of the structure looks as shown in figure 20.

Then we created a list in which we put all the elements of the Part 1 of the structure. By using the *Copy Offset* function, and setting the Y Offset to - 500 (putting minus before 500 copies it in the negative sense of the „-YY” axis), we copied the Part 1 of the structure as it is shown in figure 21.

Then, we created beams and bracings to connect the Part 1 of the structure to its copy, as shown in the Part 2 of the structure (fig. 22).

After creating the Part 2 of the structure, we copied all its elements into a list newly created, then using the *Copy Offset* function, and setting the Y Offset to - 1500, we copied the Part 2 of the structure as it is shown in figure 23; 1500 (in absolute

value) means the distance between Part 2 and its copy Part will be 1000, plus 500 from the origin of the landmark. The procedure (creating beams and bracings) was repeated between the Part 2 of the structure and its copy to create the complete structure shown in figure 24.

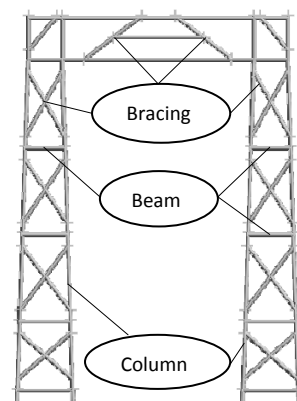


Fig. 20. Part 1 of the structure

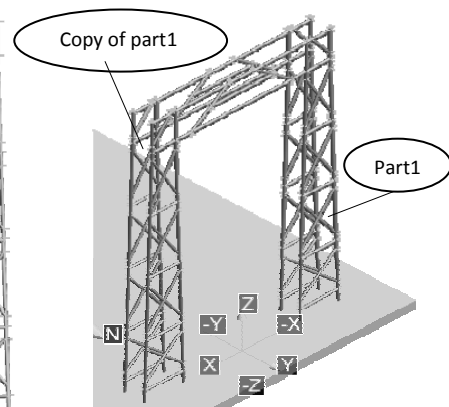


Fig. 21. Copy Offset of Part1

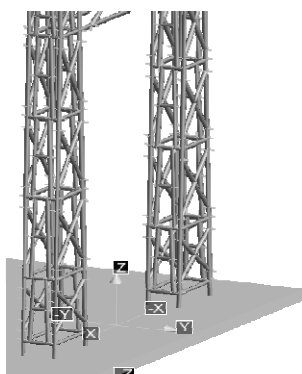


Fig. 22. Part 2 of structure

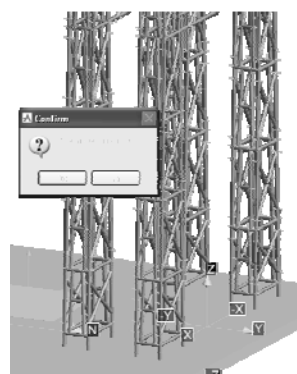


Fig. 23. Copy of Part 2

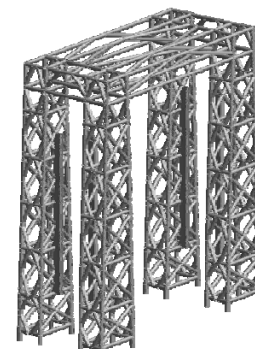


Fig. 24. Structure

Conclusions

The installation is complete, standards elements were selected at a coherent scale with all other created elements. PDMS software presents advantages and disadvantages from which some are mentioned below. The advantages of PDMS are the followings:

- The flexibility of PDMS allows the users to setup and configure a project to meet exact and detailed requirements.
- PDMS allows simulating a detailed, full size model of all the significant parts of a process plant.
- In the model huge amounts of data can be stored and it becomes a single source of engineering data for all of the sections and disciplines involved in a design project.
- PDMS contributes to the quality of the design by ensuring consistent and reliable component data, adhering to definable engineering specifications, ensuring correct geometry and connectivity, avoiding component interferences.
- Rapidity of construction, the elements are taken from the database and added to the project.
- The designer's idea is to make a montage of virtual items, but these items are only those which have a correspondent in a commercial implementation.
- Elements must match, we cannot force a montage between incompatible items, for example we cannot mount two flanges that do not match.
- A lot of details are checked, such as when we install a valve, we are sure to have also a space for opening the shank.
- It interacts well with other products such as AutoCAD, Microstation etc.

The disadvantages of PDMS are as follows:

- PDMS is difficult to learn because of the rigor of construction. Also, it is not a very well known software, courses and books of PDMS are not easy to find and are expensive.
- It does not have integrated calculation tools, for example if we have calculations related to the pipeline, it must be exported via an interface of PDMS to another program, then imported back to PDMS with the changes. It consumes time and not goes perfectly in all situations.
- Involves specialization in certain of its modules, to ensure required productivity.
- The coordination activity is enough complicated to implement.
- Company that uses it must have at least medium size, in order to cover the costs of license and training.

References

1. *** – *TM-1000 AVEVA Plant (12 Series) PDMS Hands-On Overview* Rev 3.0, 2009;
2. *** – *TM-1101 AVEVA Plant (12 Series) Structural Modelling (Basic)* Rev 4.0, 2009;
3. *** – *TM-1100 AVEVA Plant (12 Series) Pipework Modelling* Rev 4.0, 2009;
4. *** – *TM-1002 AVEVA Plant (12 Series) Drawing Production (Basic)* Rev 4.0, 2009;
5. *** – *AVEVA Equipment User Guide*, 2009;
6. *** – *AVEVA ImPLANT-I Installation and User Guide*, 2009;
7. *** – <http://www.plantcon.dk/cadchtm/PDMSImExPlant.pdf>;
8. *** – *AVEVA Cable Design User Guide*, 2009;
9. *** – *AVEVA PDMS and associated products Release 12.0 User Bulletin Service*, 2009;
10. *** – *AVEVA PDMS Reporting Reference Manual*, 2009;
11. Babe P. – *Drilling rigs modelling with the study of mounting activities*, Graduation Project, Petroleum-Gas University of Ploiesti, 2011;

12. Burcea Al. – *Wastewater plant modelling in PDMS*, Graduation Project, Petroleum-Gas University of Ploiesti, 2011;
13. Pana I. – *Computer Aided Design of Petroleum Equipment*, Master Degree Course Notes: Advanced Technologies of Design and Manufacturing of Oil Drilling-Mining Equipment, Petroleum-Gas University of Ploiesti, 2010.

Modelarea instalațiilor de foraj utilizând produsul-program AVEVA PDMS

Rezumat

Această lucrare se ocupă de modelarea unei instalații de foraj (model de laborator) cu acționare hidrostatică în programul PDMS. Proiectul constituie o parte a lucrării de disertație, obținută prin colaborarea dintre autori [11]. Modelarea constituie o premieră în cadrul realizărilor instalațiilor de foraj, programul fiind axat pe construcția instalațiilor din petrochimie. Sunt scoase în evidență avantajele utilizării programului și modul de rezolvare a temei. Lucrarea a fost posibilă datorită donației făcută de firma AVEVA a 14 licențe PDMS în cadrul unui program de colaborare cu Universitatea Petrol-Gaze din Ploiești, inițiat în anul 2010.