Design and Application of Drilling System Digital Prototype for Deepwater Drilling Platform

Xiuju Yang\textsuperscript{1,2,*}, Juan Sun\textsuperscript{1,2}, Zhiwei Zhang\textsuperscript{1,2}, Langjun Xu\textsuperscript{3}, Chunchun Wang\textsuperscript{1,2}, Zhitong Liu\textsuperscript{1,2} and Lixian Zhang\textsuperscript{1}

\textsuperscript{1}Baoji Oilfield Machinery Co., LTD, Baoji, China
\textsuperscript{2}CNPC National Engineering Research Center for Oil\&Gas Drilling Equipment Co., LTD, Baoji, China
\textsuperscript{3}Yantai CIMC Raffles Offshore Limited, China

*Corresponding author email: yangxiuju999@cnpc.com.cn

Abstract. With the rapid development of offshore oil drilling equipment industry, PDMS (Plant Design Management System) software has been widely used in offshore platform Design. Firstly, this paper combines the application of PDMS in designing the drilling system for deepwater semi-submersible offshore platform, systematically introducing the digital prototype design process based on PDMS software for the design of supporting platform (ship) drilling system. Secondly, we get the application effect of Marine engineering design based on PDMS. Finally, it is concluded that the overall layout of the platform with tight design space and high design density can be better optimized by using PDMS software, which enable multiple professionals to jointly complete the complex design process and explore an efficient Marine production mode.

Keyword: Deep water drilling platform; Drilling system; Drilling module; PDMS software; Digital prototype design.

1. Introduction
With the acceleration of the globalization process for the petroleum equipment manufacturing industry, accelerating the informatization of the marine equipment manufacturing industry, and actively exploring the business collaboration model has become a trend, and the transformation of the three-dimensional plant design system PDMS will play a powerful role in the design of the offshore platform. Promote the role. The software integrates engineering planning, design, construction, and management, and mainly covers piping, equipment, structure, electrical, instrumentation and other specialties. It can realize collaborative design and perform collision check in real time. Using this design tool can shorten the design cycle and ensure the design quality while reducing the project cost and improving competitiveness. At the same time, it can liberate the designer from the heavy drawing work, laying a foundation for the development process of modern engineering project management from passive to active\textsuperscript{[1]–[8]}. The advantages of PDMS software in the design of complex engineering pipelines such as offshore engineering are obvious. The specific advantages are summarized as follows:

- Introduce the idea of project management;
- Multi-disciplinary collaborative design;
- Simple pipeline path planning;
- Real-time collision check;
• Automatic and accurate material statistics;
• Easy and fast drawing.

2. Digital Prototype Design of Drilling System

2.1. Top Layer Design of Digital Prototype
Digital prototype design can be divided into equipment, structure, piping, outfitting, electrical and other majors according to major, and can be divided into library building, modeling, interference inspection, production information input inspection and drawing, etc. according to function. When multiple designers collaborate, the project design process is more complicated, and the designers need to be professionally divided and authorized. The staffing plan is: administrator, project leader, key designer, ordinary designer, temporary designer. The flow chart of digital prototype modeling design for the drilling system is shown in Figure 1.

![Flow chart of MEP digital prototype modeling design.](image)

2.2. Structure, Outfitting and Mechanical Modeling Design
Structural modeling takes the database as the core. When building the database, the data and the graph are unified, and will not have the mistake; the design process collision inspection may also carry on at any time, carries on the design under the three-dimensional entity environment, it can control the display and hide of the model, measure or judge the distance between objects, find the collision at any time and check the rationality of the assembly. In the same project platform, collision analysis can be done between different professional models, producing both graphics and collision interference reports. The structure and outfitting modeling flow diagram is shown in Figure 2.
It is convenient and quick to model the equipment that the owner has provided drawings. It can define any complex graphics like other 3D software and can accurately define the interface information for each equipment. The flow chart of drilling bag mechanical modeling design is shown in Figure 3.

2.3. Piping Modeling Design
In the project design, pipeline layout is generally the most problematic link, and in PDMS, pipeline modeling is one of its most powerful functions. It can improve the design quality, strictly control the selection of materials, and avoid professional collision interference and other errors of pipelines with others as much as possible. Pipeline modeling usually adopts the method of "pipe guiding pipe"[8]. When modeling, you only need to define the beginning and end positions, and the software will automatically complete the pipe layout path of the pipe. The flow chart of piping modeling design is shown in Figure 4.

The complex structure of the pipeline network, coupled with the large number of platform equipment and structural parts, interference will occur when the pipeline path is planned with little care. The software comes with a collision check function. When a collision occurs, the collision part will be highlighted in red. This function is very helpful for the design of the pipeline. The interference parts shown in the collision inspection of the pipeline and the equipment are shown in Figure 5. At the same time, the pipeline model can also show the engineering design parameters and additional parameters such as pressure, temperature, insulation and heat tracing required by the pipeline required in engineering design.

The pipe support plays the role of adjusting the pipe flexibility and supporting the pipe, which is essential in pipe layout design. PDMS sets standard pipe supports as templates and integrates them into MDS. From THE MDS into the project, it is convenient to choose the form, material,
specification and adjusting position of pipe supports. The template-type pipe support modeling and drawing are the special functions of PDMS, which save a lot of time for the model drawing of pipe support. Figure 6 shows several typical tubular support models in the project.

2.4. Electrical Modeling Design

In the project of electrical equipment, electrical fittings and path in the main cable, modeling, and according to the shipyard mode, to guide the construction. Such modeling and figure out ways to produce electrical construction work ahead of time to design, and drawing content elaboration to each size precision, improve the efficiency of field construction, improve the quality of the product. The structural data is stored according to the electrical data hierarchy. The electrical data hierarchy cannot be saved by crossing as shown in Figure 7. The modeling of electrical equipment and cables is not possible with structures or piping and must be completed by starting the modeling of equipment.

2.5. Production Design

PDMS has good scalability and secondary development capability. According to users' needs, we can customize the drawing style and various forms of reporting according to the shipyard or users' requirements. Automatically according to the requirements of the design development of PDMS parts named to a small program, CAD drawings automatically in order to merge small procedures, 2 d graphics automatic tagging each view coordinates small programs, from CAD to create any custom graphics import PDMS small programs, as well as the structure, iron snoop-proof, piping, electrical, report forms according to the demand of the drawing template automatically drawing program, etc. With the continuous use and design of PDMS software, there will be some suitable for the design needs, convenient application of small programs have been developed and used. These can effectively improve production efficiency and reduce the labor intensity of designers. The secondary development program of PDMS software can be used to input and check the production information of the parts. The input information can be reflected in the title bar and details of the drawing after the drawing. The program can also be used to export the production information of the parts to obtain the production information table and material list statistics for the subsequent
production and processing. And PDMS has the function of quickly generating reports on has designed a 3 d model, can be in the form of EXCEL file output information that users need, especially the design of the structure of the bill of materials can be set according to the selected modules, assembly space and a good template output, direct forming production materials, statistics and rapid time efficiently.

The production drawing output preparation is summarized as follows:

- Establishment of structure, outfitting, equipment, piping and electrical models
- Each profession completes the interference inspection, modifies the interference model
- Add part production information
- Input and check production information, modify parts production information
- Enter the DRAFT module
- Process check, return the DESIGN module to modify the relevant production information
- Output production drawing

According to the needs of each profession, automatically generate all kinds of required drawings. The drawing style of this software is slightly different from the traditional CAD drawing style. This drawing style can reduce the labor intensity of the machining personnel and make the pipelining operation mode in the machining process possible.

To have designed the 3 d model, PDMS has the function of quickly generating reports can be output in the form of EXCEL file users the information they need to, especially the design of the structure of the bill of materials can be set according to the selected modules, assembly space and a good template output, direct forming production materials, statistics and rapid time efficiently.

3. Application and Effect

In the process of using PDMS software to design the digital prototype of the drilling package, the following problems are mainly solved and certain technical accumulation is obtained.

3.1. Realizing the "Collaborative Office" Project Management Mode

In terms of configuration optimization of projects, PDMS can break the conventional design habit. In the process of project design, it is not necessary for every designer to be familiar with every major, but to make his/her own 3D model and modify the model until the drawing is made. PDMS is a pipelined workflow pattern, which divides the roles of designers according to the design process. Let each professional designer focus on their own field of work, improve the work efficiency of the project. With PDMS, the number of 3D designers will be reduced, and the overall optimization of the personnel allocation throughout the project will result in fewer designers and efficient operation compared with conventional designs [9].

The REVIEW interface can provide realistic pictures with photo characteristics, anti-blur and projection, and can generate and record complex dynamic roaming diagrams. It can make various observations from the perspective of people, enabling the project staff to check engineering information at any time. This feature can improve design efficiency and reduce design errors.

PDMS has good scalability and secondary development capability. According to users' needs, we can customize the drawing style and various forms of reporting according to the shipyard or users' requirements. An important aspect of PDMS development is that users are constantly improving themselves in the process of using PDMS. Users can define a large number of common components and devices, which makes the project more reusable. Enterprises can also customize PDMS enterprise standards and PDMS operating guidelines according to their own project structure needs, to urge designers to organize the done generic data into the corresponding database, so that the PDMS in the process of use is constantly enriched.

3.2. Exploring Efficient Marine Production Model

According to the needs of each profession, automatically generate the drawings required by each profession. The drawing mode of this software is different from the traditional CAD drawing mode. Meanwhile, the processing means are somewhat heavy, such as heavy welding, light machine addition
and precision control, etc., which make the product design more in line with the habit of Marine construction. The advantages of the production mode lie in that the drawing mode can reduce the production burden, reduce the labor intensity of workers, and make the pipelined operation mode in the processing process possible.

3.3. Presenting an Innovative 3 D Dynamic Design Method for Cable

In accordance with the SFI system coding rules, the code standard of drilling encapsulation system is formulated. In the establishment of piping system model, each pipe branch and pipe fitting is named and classified according to the code, so as to make the piping more orderly and standardized and improve the appearance quality of products \[10\].

Model the electrical equipment, outfitting and main cable path, guide the field construction. The electrical production and construction work was advanced to the design stage, and the drawing content was refined to each precise size, which improved the on-site construction efficiency. While improving product quality, it also improves the appearance of product quality and makes electrical design more standardized.

![Figure 8. Dynamic design results of piping system.](image1)

![Figure 9. Dynamic design results of cable.](image2)

4. Application

The problem of improper layout caused by incorrect lofting of piping and cables was solved, and the problems caused by improper lofting were solved at the design stage in advance, so as to better guide the production and processing, reduce the rectification rate and improve the appearance quality of products.

Before the new prototype is installed and debugged, the modules are installed and butted in the virtual interface, so as to optimize the whole scheme of interference or unreasonable structure, standardize the modeling and drawing mode, and carry out multi-professional cooperative design, improve the quality of interface design, shorten the product development cycle, reduce on-site debugging safety risk and correction rate.

5. Conclusion

PDMS in semi-submersible drilling system for Marine platform design, the application of professional designers can make each coordination office, the tacit understanding coordination, so as to reduce design errors, effectively prevent interference, reduced the modification and rework time, improve the efficiency of the figure, and ensure the quality of the work, makes the steady and efficient design of offshore drilling system. The application of PDMS software in the design of offshore drilling platform can enable the integration of design and management, so as to establish the offshore oil platform drilling system database in the design of offshore engineering. The powerful parameterization and exploitable performance of PDMS can lay a solid foundation for the research and development of offshore engineering projects.

Acknowledgments

Ministry of Industry and Information Technology“ Seventh Generation Super Deepwater Drilling Platform (Ship) Innovation Special”-“Application Research of Drilling Package Integration and Some Key Equipment” Project (Ministry of Industry and Information Technology Joint installed[2016]24) ..
References

[1] Dingya Wang, Ping Li. Current Status and Development Trend of offshore drilling Platform Technology. Petroleum Machinery[J]. 2010 (4): 71-73.

[2] Aveva. PDMS Training Materials[M]. 2009

[3] Xuan Liu, Yanfeng Han. Application of PDMS 3d software in Marine engineering[J]. China shipbuilding supplement, 2011, 52 (1): 224-228.

[4] Meili Cui. Application of PDMS in the THREE-DIMENSIONAL Design and Management of General Drawings[D]. Master thesis of Xi’an University of Architecture and Technology, 2011.

[5] Xiangyong Wu, Yi Li, Qinwu Lu, Yalin Luo, Jie Mao, Zhen Li. Research and development of module 3d design system based on PDMS platform[J]. Nuclear power engineering supplement, 2011, 32 (2): 127-132.

[6] Jia Jin, Xuan Liu. Assumption and Research on Pipeline Automation Based on PDMS[J]. Petroleum Engineering Construction, 2011, 37: 52-54.

[7] Xiuju Yang, Yongsheng Liu, Yahui Li, Bo Zhao, Lan Wang. Offshore Platform Drilling System Design based on PDMS Software[J]. Mechanical Engineer, 2016 (2): 168-171.

[8] Huan Xu, Fei Xu, Xiang Shen. Some Thoughts on Optimization of Ship Pipeline Layout[J]. Ship Materials and Market, 2020 (05): 1-2.

[9] Liang Pang. Discussion on the collaborative design of PDMS software platform[J]. Petrochemical design, 2020, 37 (01): 56-58+66+8.

[10] Yongsheng Liu, Chenghua Mai, Peng Zhang, Nan Hu, Xiuju Yang, Jingxiang Wang. Application of PDMS software in pipeline design supporting platform[J]. Chemical equipment and pipelines, 2017, 54 (3): 80-82.