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Application of Pipe Handler in Songliao Basin Drilling Project

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Abstract: Continental scientific drilling is a way to understand the processes and structures of the Earth. Songliao Basin Drilling Project CCSD-SKII was implemented in Northeast China to obtain the Cretaceous continental sedimentary record. Continental Scientific Drilling Project of Cretaceous Songliao Basin is introduced in this paper. To meet the continuous coring need of CCSD-SKII, Pipe handler was designed to rack drill-stands automatically and efficiently. Dynamic modeling and simulation was carried out to verify the stability and reliability. After installed in 'Crust 1' 10k drilling rig, Pipe handler was also extensively tested and debugged. Pipe handler is now racking drill-stands in CCSD-SKII scientific drilling site without a derrickman.

Keywords: *Songliao Basin Drilling Project; 'Crust 1' 10k drilling rig; Pipe handler; Dynamic simulation; Continental scientific drilling*

1. Introduction

Since International Continental Scientific Drilling Program (ICDP) was founded in 1996, great advances have been brought about in many fields of earth sciences by continental scientific drilling [1]. Until now, scientific drilling has been the unique method in our understanding of the processes and structures of the Earth [2-4]. Continental scientific drilling is like a telescope protruding into the interior of the earth, and is a frontier field of earth sciences [5]. As a founding member of ICDP, China has carried out 4 scientific drilling projects1: Chinese Continental Scientific Drilling Project (CCSD-1), Scientific Drilling at Lake Qinghai on the northeastern Tibetan Plateau (CESD), Terrestrial Scientific Drilling Project of the Cretaceous Songliao Basin (CCSD-SKI), Wenchuan Fault Scientific Drilling Program (WFSD).

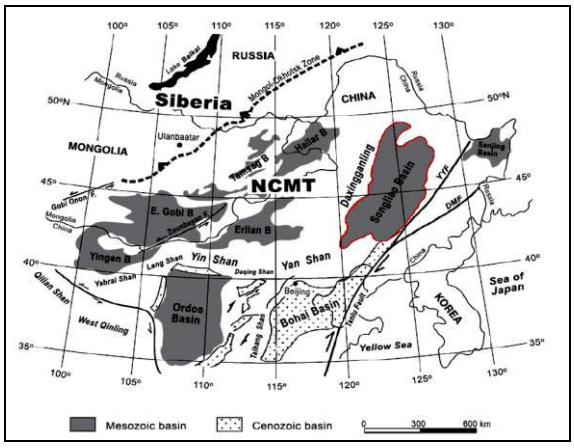

Figure 1: *Location of Songliao Basin in tectonic framework of the northern China- Mongolia tract (NCMT) - © Chengshan Wang*

The SinoProbe Program is the Chinese government-funded earth science program with the overall aim of exploring the composition, structure and evolution of the continental lithosphere beneath China and the processes causing earthquakes, geo-hazards and natural resources. In this program, Jilin University designed and conducted Chinese first 10K scientific drilling rig and auxiliary automation equipment. The whole set of 'Crust 1' drilling rig was designed for the Songliao Basin Drilling Project CCSD-SKII.

CCSD-SKII will be the world's first borehole to drill through the Cretaceous continental strata of continental scientific drilling well, whose design depth is 6400m, is so far the deepest scientific drilling project funded by ICDP, also China's deepest scientific drilling well.

CCSD-SKI is a well completed in October 2007, which finished drilling with total core length 2485.89m after a year of efforts [6].

Implementation of CCSD-SKII will acquire approximately 3600m of core., the two wells will implement the 6400 meters of continuous coring, constitute the world's first nearly complete Cretaceous continental sedimentary record [7]. A study of the core will provide unique opportunities for the geosciences community to understand the response of terrestrial environment to geological events related to the carbon cycle and greenhouse climate change during Cretaceous, which would be of help to inform our understanding of modern global warming [8]. The project will also lay a solid foundation for the sustainable development of Daqing Oilfield.

Coring of CCSD-SKII will be performed from 2865 to 6400m to recover the continuous high resolution sedimentary record with the designed core recovery greater than 95%.

Table 1: *Coring schedule of CCSD-SKII*

Layer	Coring segment (m)	Coring footage (m)	Coring drill bit (mm)	Coring rate
Section 2 of Nenjiang Group	1074～1134	60	Φ215.9mm	
Section 1 of Nenjiang Group	1185～1245	60	Φ215.9mm	
Denglouku Group	2865～2965	100	Φ152mm	
Yingcheng Group	2965～3320	355	Φ152mm	≥95%
Shahezi Group	3320～4500	1180	Φ152mm	
	4500～5670	1170	Φ215.9mm	
Huoshiling Group	5670～5800	130	Φ215.9mm	
	5800～6240	440	Φ150mm	
Base	6240～6400	160	Φ150mm	
Total		3655		

Due to CCSD-SKII scientific drilling requires continuous coring, additional tripping operation will be needed other than replacement of drill bit, resulting in massive auxiliary time. To meet the continuous coring need of scientific drilling project, to reduce auxiliary time and improve drilling efficiency, key automation equipment was designed, including Top-drive system, Pipe handler, Iron roughneck and Power catwalk.

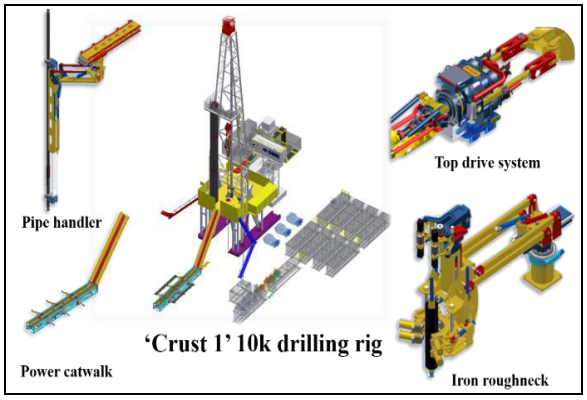

Figure 2: *Scheme of 'Crust 1' 10K drilling rig and key automation equipment*

2. Dynamic modeling and simulation of Pipe Handler:

While tripping or making connections, drill string are frequently transmitted between the wellbore to and from the pipe storage. A present method of manual tripping requires a person to stand on the racking board for the duration of the round trip. Pipe racking system, which has been used widely in offshore drilling platform, makes a tripping without a derrickman, this greatly improves personal safety and operation efficiency, and decrease time during a tripping. Pipe Handler racks drill-stands mechanically.

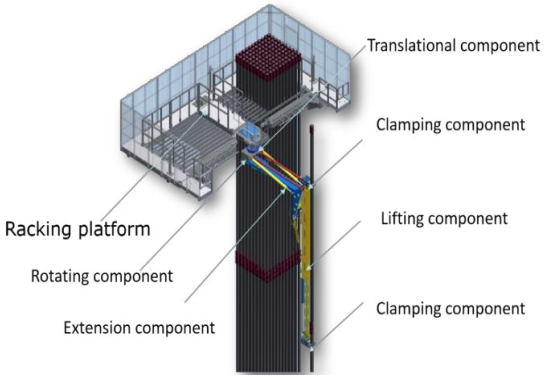

Figure 3: *Components of Pipe handler*

Pipe handler is a drill-stand transmitting system suitable in K-type derrick for onshore drilling platform. This system is portable and hanged under the monkeyboard. It's composed of translation component, lifting component, rotating component, extension component, and clamping component, while racking drill-stands, these components operates in a sequence. In order to verify the rationality and reliability of the mechanism design, dynamic modeling and simulation of Pipe handler is carried out by ADAMS®. Adams helps engineers to study the dynamics of moving parts, and how loads and forces are distributed throughout mechanical systems [9].

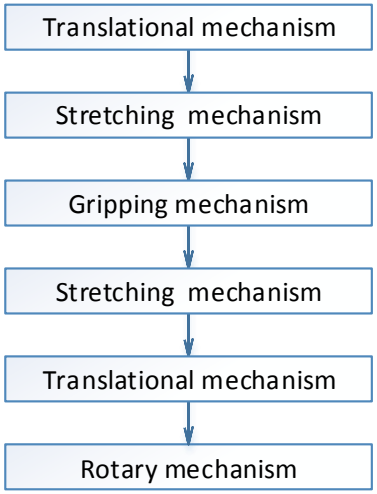

Figure 4: *Sequence of Pipe handler's mechanisms during a racking operation*

Table 2: *Parameters of Pipe handler*

Maximum translation	Rotary angle	Maximum reach angle	Maximum stretch
2150[mm]	-90º—0º—90º	0—80º	2400[mm]

Table 3: *Input parameters of Pipe handler's components*

Component	Input parameters
Rotating component	Step (time,0,0,34,0)+ step (time,34,0,37,-90d) +step (time,37,0,40,0)
Translation component	Step (time,0,0,5,-2100)+ step (time,5,0,10,0) +step (time,10,0,13,950) + step (time,13,0,25,0)
Extension component	Step (time,0,0,13,0) + step (time,13,0,16,-690) + step (time,16,0,19,0) + step (time,19,0,22,690) + step (time,22,0,28,0) + step (time,37,0,40,-690)+ step (time,40,0,43,0)
Clamping component	Step (time,0,0,16,0) + step (time,16,0,19,40)+ step (time,19,0,40,0)

Pipe handler is designed to grip drill-stands varies fromΦ89-Φ168mm, and the lifting capacity is up to 2000kg.In order to simulate the process of Pipe handler racking drill-stands accurately, complete dynamic model was established, including a Φ127mm drill-stand (consists of 3 single drill pipes). Simulation time was set 40s, during which, Pipe handler moved from near the wellbore to the drill-stand to perform the grip operation, then migrated to wellbore together with the drill-stand, this is a whole racking operation.

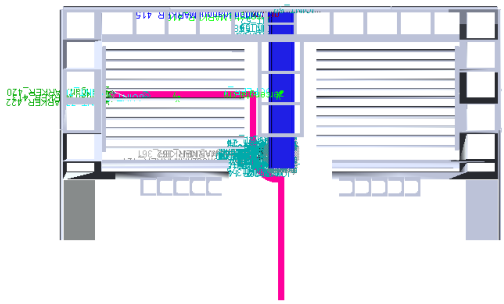

Figure 6: *Migration path of drill-stand (vertical view)*

Input parameters of Pipe handler's components is defined based on its hydraulic system, and expressed with step function.

The displacement of drill-stand in the migration process is shown in Figure 6. As can be seen from Figure 7, the migration velocity of drill-stand is relatively stable. The Acceleration - Time graph of drill-stand shown in Figure 8 indicates that the acceleration of drill-stand varies a lot but acceptable only when the clamping action is executed. Therefore in the process of migration Pipe handler is relatively stable and reliable.

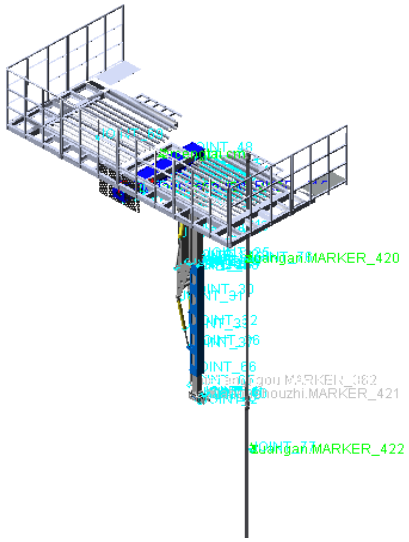

Figure 5: *Dynamic model of Pipe handler in ADAMS®*

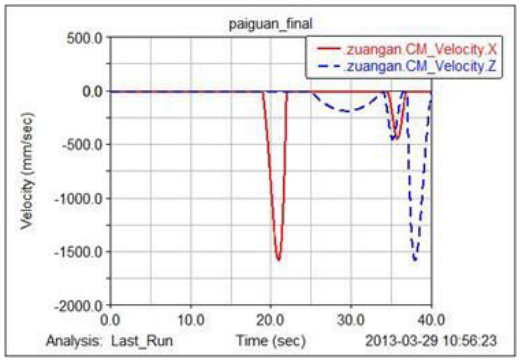

Figure 7: Speed - *Time graph of drill-stand (x, z-axis)*

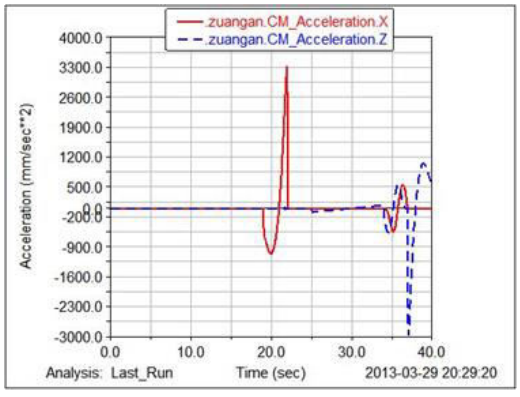

Figure 8: *Acceleration - Time graph of drill-stand (x, z-axis)*

3. Application of Pipe Handler in CCSD-SKII:

In April 13, 2014, CCSD-SKII spud in, drill-stands were racked manually since then. Derrickman worked at about 25m high from the drill floor, with great risk and low efficiency. In August 2014, Pipe handler was transported to CCSD-SKII drilling site, then was mounted under the racking board. Pipe handler can be operated both locally and remotely with its control box on the drill floor.

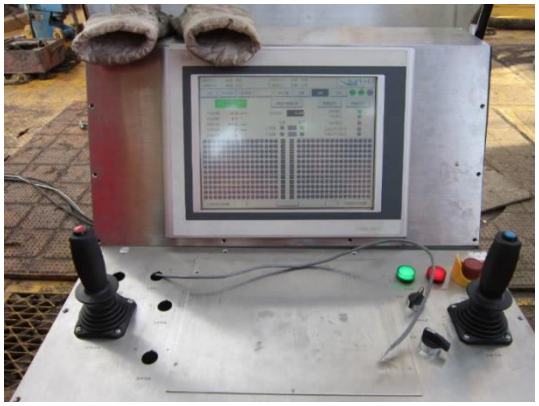

Figure 9: *Control panel of Pipe Handler (on the drill floor)*

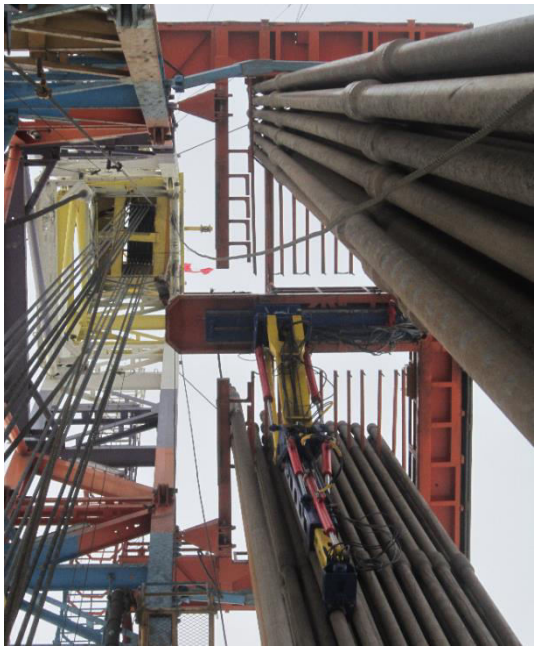

Figure 10: *Pipe handler gripping drill-stand*

After installation, Pipe handler was extensively tested and debugged. Pipe handler can meet the demand of massive racking operation of drill-stands. Pipe handler can save auxiliary time, reduce labor intensity, and realize unmanned operation on the racking board with Top-drive system and hydraulic elevator.

4. Conclusion:

To meet the continuous coring need of CCSD-SKII scientific drilling project, to reduce auxiliary time and improve drilling efficiency, key automation equipment was designed, including Top-drive system, Pipe handler, Iron roughneck and Power catwalk. Pipe handler was designed and made to rack drill-stands automatically and save additional auxiliary time caused by tripping operation of continuous coring. Dynamic simulation was carried out to prove the dynamic performance of Pipe handler. Test and debug of Pipe handler indicates that it can replace derrickman's manual operation with safe, reliable and efficient automatic operation. Pipe handler is capable of massive tripping operations in CCSD-SKII scientific drilling project.

5. Acknowledgements:

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References

[1] You Hong Sun, Jian She Mao. Advances of Continental Scientific Drilling Programs in China [J]. *International Journal of Earth Sciences and Engineering*, 2014, 2:5-15

[2] SU De-chen, YANG Jing-sui. Advances of international continental scientific drilling program [J]. *ACTA Geological Sinaca*, 2010,84(6):873-886 (in Chinese)

[3] Min Zhi, Zhang Liang-bi, Yang Wen-cai. Continental scientific drilling: the discoveries and key scientific subjects [J]. *Advance in Earth Science*, 1998,13(1):15-21 (in Chinese)

[4] Xu Zhi-qin, Zhang Liang-bi. Present situation of continental scientific drilling in China and its prospects [J]. *Progress in Geophysics*, 1994,9(4):55-65 (in Chinese)

[5] Xu Zhi-qin, Yang Wen-cai, Zhang Ze-ming, YANG Tian-nan. Scientific significance and site-selection researches of the first Chinese continental scientific deep drillhole [J]. *Continental Dynamics*, 1998,3(Z1):1-13

[6] Cheng Shan Wang, Zhi Qiang Feng. China Cretaceous Continental Scientific Drilling Project: Implementation and initial progress of SKI [J]. *Acta Geologica Sinica*, 2008,82(1):9-20 (in Chinese)

[7] Zhiqiang Feng, Chengshan Wang, Stephan Graham, Christian Koeberl, Hailiang Dong, Yongjian Huang, Yuan Gao. Continental Scientific Drilling Project of Cretaceous Songliao Basin: Scientific objectives and drilling technology [J]. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 2013,385(1):6-16

[8] http://www.icdp-online.org/

[9] http://www.mscsoftware.com/product/adams