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WORKING RIG MACHINES FOR DEEP DRILLING 7500 PSI RATED DRILLING EQUIPMENT FOR THE FUTURE******

1. INTRODUCTION

Oil and natural gas resources are not unlimited. They may turn out to be close to be depleted some time in the nearest future. This mainly applies to oil. A very important question of the magnitude of the oil and natural gas resources arises, but nobody knows the answer to it. According to one of the present theories we know about ca. 1000 mld barrels (ca. 140 mld ton) in reservoirs, and some 500 to 800 mld barrels of oil are still left "under surface". These data have not been verified yet, and only discovering new fields and reservoirs can prove their existence. Another problem is related to the uneven distribution of oil and gas. The OPEC countries have ca. 60 to 70% of World's resources. One of the ways of solving the problems resulting from the depletion of hydrocarbons is intensification of prospecting. There are still places where hydrocarbons can be discovered, as practice reveals.

New deposits can be now found at greater depths, either on land or offshore. In the latter case the depth of water is greater, therefore rig vessels of higher deadweight capacity are needed. Drilling works in such conditions require on the part of the Operator the multifunction ability to perform them best and also to have equipment providing safe performance of a given operation. The efficiency of finding new deposits and their exploitation depends on drilling more complex and longer directional boreholes. Especially for marine drillings, where exploration will concentrate in the nearest future, the efficiency of finding

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new deposits is conditioned by drilling more complex and longer directional boreholes in places where the sea is deeper. This will require higher deadweight capacity of the rig vessel, more powerful mud pumps and machines of high torque on the string.

The practice reveals that greatest investments on the technical and technological development are directed to research institutions specializing in designing marine drilling equipment as the operations in the sea are most costly.

Prospecting at greater depths (land) and at greater water depths (seas and oceans) is technologically more challenging for the designers, producers and users for a number of reasons, e.g. difficult geologic conditions, unfavorable siting, technological obstacles, complex climatic conditions, smaller size of productive reservoirs as well as strict environmental and safety regulations.

This necessitates using more efficient technical solutions.

The basic design parameters of a drilling rig, i.e. hoisting capacity, hydraulic capacity of mud pumps or torque of driving machines on the string [3] are difficult technical obstacles. Designer's works concentrate on equipment to be used for safe and reliable prospecting in areas which have not been checked out with drilling wells so far.

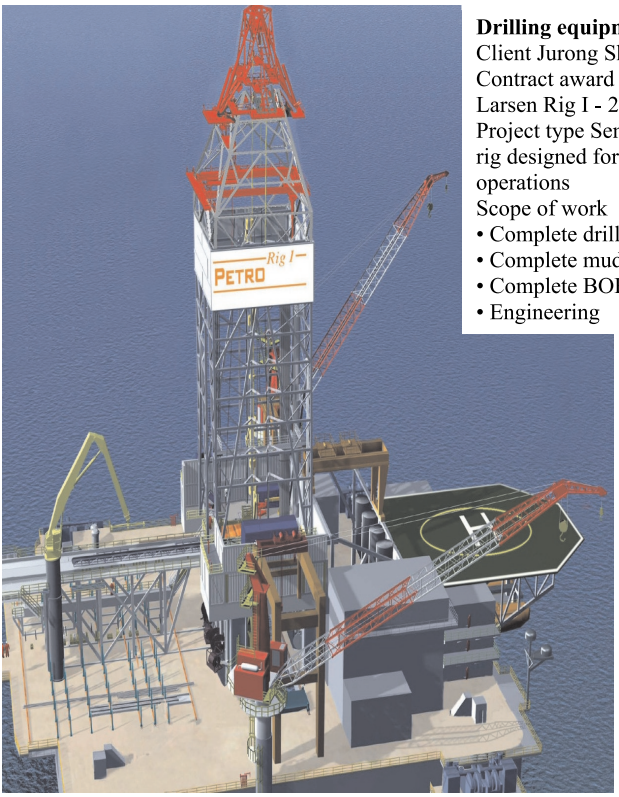
Among such areas are:

- Spitsbergen,
- Barents Sea,
- Arctic Area,
- Brasil Shelf,
- deeper areas of the Gulf of Mexico.

Further development of oil fields is one of the most difficult and most expensive power projects.

The designers face these challenges. At present novel designs of rig vessels for prospecting operations in the above mentioned perspective areas are realized, e.g. Aker MH apart from on shore drilling equipment is involved in delivering 30 new drilling units for offshore drilling industry. Apart from commonly used vessels, there are also new designs (semi-submersible platforms and rig vessels). These are, e.g. **Sevan** (presently used for drilling in deep waters to 3 048 m (10 000 ft), or newly designed ones for frilling in water depths to 3 657 m (12 000 ft) and more: **Larsen Rig I** (Fig. 1) and PetroRig 1, 2, 3, **Aker Spitsbergen & Aker Barents –** drilling unit with a dual hydraulic mast (Fig. 2), which is not equipped with a traditional hoist, is an example of a new trend in the drilling rig design based on power hydraulics [1, 2]. Other producers also actively get prepared to explorations at deeper sea areas, e.g. MPF Corp. (vessel **MPF01**) or Stena, (drilling vessel **Stena DrillMAX**) (Fig. 3).

The designers are faced with the need of meeting high requirements regarding exploration and exploitation equipment that can manage the tasks.



Drilling equipment – Larsen Rig I
Client Jurong Shipyard
Contract award – Larsen Rig I 2008
Larsen Rig I - 2011
Project type Semi submersible drilling rig designed for ultra deepwater operations
Scope of work
• Complete drilling equipment package
• Complete mud equipment package
• Complete BOP & marine riser system
• Engineering

Fig. 1. Semi-submersible drilling platform Larsen Rig I with traditional hoist system for operation in very deep water [6]

2. RIGS

Rigs (Fig. 1, 2 and 3) are sets of machines making up the following subsystems:

- Hoist systems,
- Systems transmitting torque on the string and drilling tool [3],
- Mud systems,
- Cementation systems,
- Piping (drilling strings, casing, risers),
- Systems for moving pipes, BOP and production heads [5],
- BOP heads systems,
- Control, registration, monitoring and communication systems,
- Compensating systems,
- Driving and positioning systems,
- Other subsystems cooperating with above mentioned ones, as well as tools and auxiliary drilling equipment.

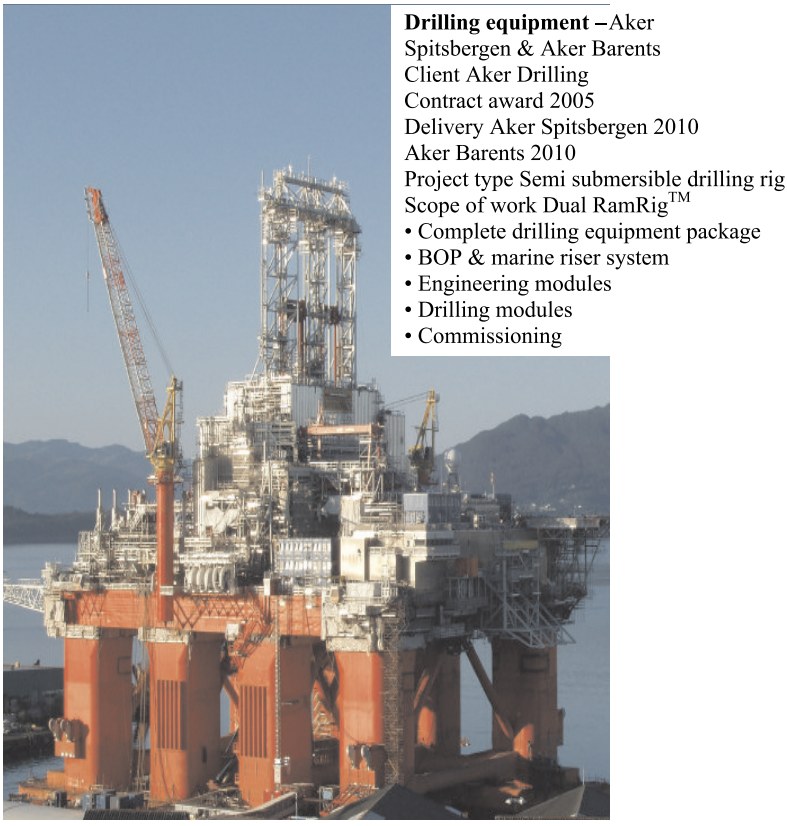


Fig. 2. Semi-submersible drilling platform Aker Spitsbergen & Aker Barents dynamically positioned, with dual hydraulic mast Ram Rig for operation in very deep water [2, 6]

The above reveals that rigs are systems of complex subsystems and machines, where the transmission of the forces and torques is the basic principle of its design. Generally, driving of a rig is reduced to finding an appropriate motor or set of motors with a control system, and protection of working machines to provide correct performance of a technological task. The drive is responsible for putting working machines in operation, depending on their function. Driving system of a rig consists of a set of high power machines, the energy of which is supplied to specific working machines. Above-mentioned rigs should be equipped with working machines having high-technological parameters, which have not been applied to drilling operations so far. When drilling longer boreholes, the mud pump becomes a very important drilling technology factor. It should provide an uninterrupted movement of drilling mud in the borehole and also overcome considerable pumping resistance to provide sufficient amount of energy to the downhole motor driving the rig. The hoist system with a driving head [3] should provide safe and efficient performance of high-load hoisting operations. Therefore high power and highly reliable working machines have to be used.

Stena DrillMAX

PRINCIPAL CHARACTERISTICS

DIMENSIONS	API	METRIC
Overall length	748.03 ft	228.0 m
Breadth, mld.	137.80 ft	42.0 m
Depth, mld.	62.34 ft	19.0 m
Moonpool	84 ft x 41 ft	25.6 m x 12.5 m
Transit draught, mld.	26.25 ft	8.5 m
Operation draught, mld.	39.37 ft	12.0 m
Displacement	105,822 St	96,000 Mt
Variable Deck Load (approx)	16,535 St	15,000 Mt
Transit Speed	12 knots	12 knots

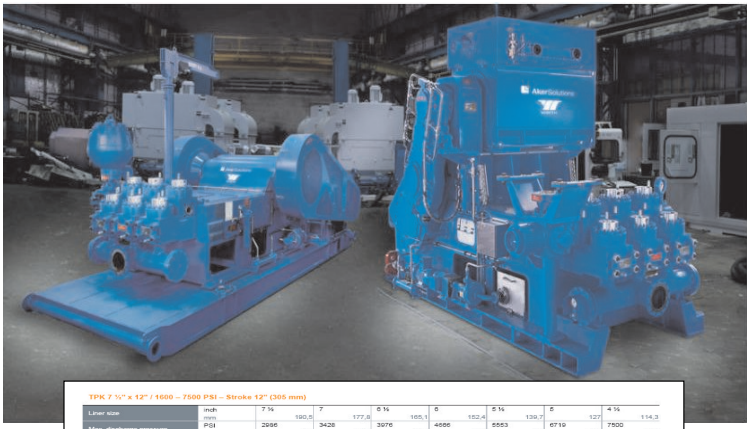
CLASSIFICATION
DnV, +1A1, Ship-shaped drilling unit(N), Drill(N), CRANE, HELDK-SH, DYNPOS-AUTRO, F-AM, EO

RATED WATER DEPTH
Capable of operating in 10,000 ft of water

DYNAMIC POSITIONING SYSTEM
DP3
Reference system:
- 2 x Hydro-acoustic HiPap
- 2 x DGPS
- 2 x taut wire
- Riser Management System

Fig. 3. Vessel dynamically positioned with a dual mast and traditional hoist system for operation in very deep water [Stena]

For instance, the new drilling rigs presented are equipped with the following working machines: mud pumps (Fig. 4), drilling hoist (Fig. 5) and drive heads (Fig. 5), with automated maneouvreing systems [4] produced by: Aker MH and Aker Wirth, which have newest design, enabling exploration explorations with very high technical parameters of capacity of hoist systems 1250 T and power of mud pumps 3300 KM [5, 6].



TPK 7 ¼" x 12" / 1600 – 7500 PSI – Stroke 12" (305 mm)

Liner size	inch / mm	7 ¼ 190,5	7 177,8	6 ½ 165,1	6 152,4	5 ½ 139,7	5 127	4 ½ 114,3
Max. discharge pressure	PSI / bar	2896 200	3428 236	3976 274	4666 322	5553 383	6719 463	7500 517
Volume per stroke	US Gallons / Litres	6.89 26.08	6.00 22.70	5.17 19.58	4.41 16.69	3.70 14.02	3.06 11.58	2.46 9.38

Pump speed SPM	Max. input power kW	HP	Discharge flow US Gallons / min. Discharge flow Litres / min.							
120	1193	1600	826 3127	720 2724	621 2349	529 2002	444 1682	367 1390	297 1126	
110	1093	1466	757 2867	660 2497	569 2153	486 1839	407 1542	337 1274	273 1032	
100	994	1333	689 2608	600 2270	517 1958	441 1668	370 1402	306 1158	248 938	
90	895	1200	620 2346	540 2043	465 1762	397 1501	333 1261	275 1042	223 844	
80	795	1066	551 2085	480 1818	414 1566	353 1334	296 1121	246 927	198 751	
70	696	933	482 1824	420 1589	362 1370	308 1166	259 981	214 811	174 657	
60	596	800	413 1564	360 1362	310 1175	264 1001	222 841	184 696	149 563	
50	497	666	344 1303	300 1135	259 979	220 834	185 701	153 579	124 469	
40	398	533	275 1042	240 908	207 783	176 667	148 561	122 463	99 375	
30	299	400	207 783	180 681	155 587	132 500	111 420	92 347	74 281	
20	199	267	138 521	120 454	103 392	88 334	74 280	61 232	50 188	

Based on vol. efficiency: 100%
mech. efficiency: 90%

HP = Horse power (1 HP = 0.746 kW)
SPM = Strokes / min.

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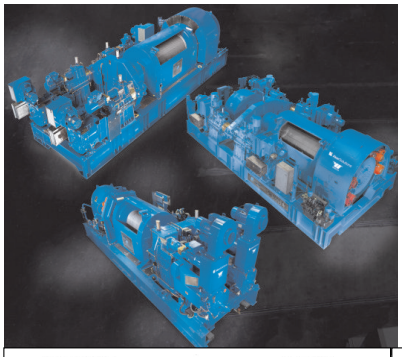
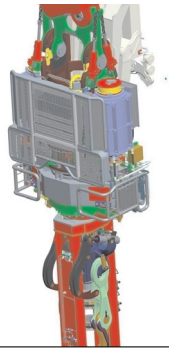
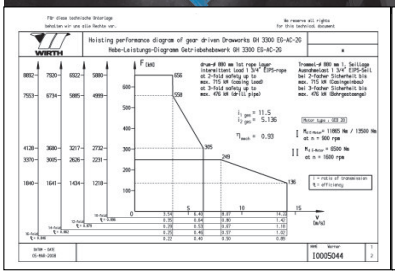
Fig. 4. Mud pump by Aker Wirth 2 200 KM of power and 7 500 psi of pressure [5]







MDDM 1250	
Lifting capacity:	1250 tons
API Rotating capacity	1250 tons
Static bearing capacity	7980 tons
Shaft connections	NC77
Drilling torque	101 000 ft lbs (113 rpm)
Max speed	282
Make up torque	120 000 ft lbs
Break out torque	151 000 ft lbs
Drilling power	2540 hp
Tubulars handled	5"-12 ½" OD

Fig. 5. Drilling hoists of 3 300 KM of power and top drive MDDM of 1 250 tones capacity and 2550 KM power [1, 3, 5]

3. CONCLUSIONS

The decreasing number of easily accessible reservoirs, the growing number of drilling operations, increasing complexity of drilling operations, more complex drilling wells, more multidirectional and directional boreholes, wells with high reservoir pressure, extreme drilling conditions, new technologies, increasing efficiency, growing oil and natural gas prices are the most important technological challenges set before designers of drilling equipment. The more and more severe requirements: higher hoist capacity, higher mud pressure, higher power of mud pumps, hoists and driving heads require specialist technical knowledge at the highest level of design and realization.

The presented rig and its basic working machines are examples of such equipment, thanks to which exploration and exploitation of hydrocarbons can be performed at great depths, unavailable for traditional rigs so far.

REFERENCES

[1] Artymiuk J.: *Nowoczesność i trendy w budowie urządzeń wiertniczych*. Wiadomości Naftowe i Gazownicze, nr 11, listopad 2006, 6–14

[2] Artymiuk J.: *A new concept drilling hoisting systems rigs*. Acta Montanistica Slovaca, Kosice, Rocnik 11, 1/2006, 1–9

[3] Artymiuk J., Loland J.: *Top drive technology-electric PTD. Nové poznatky v oblasti vrtania, tazby, dopravy a uskladnovania uhl'ovodíkov*. Podbanské 2002: XI Medzinárodná Vedecko-Technická Konferencia, 29–31 októbra 2002, Podbanské, Slovensko, conference contributions Technická Univerzita v Kosiciach. Fakulta Baníctva, Ekológie, Riadenia a Geotechnológií, 3–11

[4] Artymiuk J., Sokalski M.: *Nowe technologie w wiertnictwie – automatyzacja procesu manewrowania rurami*. 14-th Internacional Scientific and Technical Conference, „New Methods Technologies in Petroleum Geology", Drilling and Reservoir Engineering, Zakopane, 11–13 czerwca 2003

[5] Stationery Aker Wirth, 2009

[6] Stationery Aker MH, 2009