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## OPTIMIZATION METHODS OF DRILLING HYDRAULICS IN DEEP WELLS

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**Abstract.** *In article ways of deep oil and gas well hydraulic program's optimization are described. Necessity of transition from traditionally used standard sizes of 127 mm drill pipes to new types of drill pipes – 139,7 mm with double shoulder connection is established. Advantages of application of such pipes are shown: decrease in total hydraulic losses inside pipes and annulus on 30-60 %, increase in durability of drill string on a pipe body on 10 %, increase in stiffness of pipes on 36 % that raises resistance to a sinusoidal and helical buckling.*

**Keywords:** *optimization of well drilling hydraulics, joints “double shoulder”, improved drillability factors*

One among the others optimization ways of drilling processes calls for increase of pressure difference applied on the bit in sum of total working pressure applied on the pumping unit. Deep wells call for a unique solution of this problem – reduction of pressure losses in the interior of the landed drill string assembly. Drilling process of deep wells located within West and East Siberian and polar hydrocarbon fields traditionally calls for 127 mm drill pipes. Meanwhile, required optimization of generated drilling programs endeavors the drillers to use 139,7 mm drill pipes instead of 127,0 mm drill pipes, though. In full compliance with available calculations, any use of drill pipes with standard types of joints (GOST R 50278-92; GOST 27834-95; API Spec 5D, API RP 7G) triggers pressure losses up to 40 % in drilling joints (incorporated into total pressure losses documented in the interior of drill pipes). In virtue of the above, further reduction of pressure losses in connecting joints calls for a reasonable choice of joints for drill pipes. Nowadays, both domestic and foreign producers offer drill pipes equipped with a special joint; this joint has been reinforced with a double shoulder. Double shoulder joints demonstrate following advantages:

- Maximally feasible interior diameter;
- Minimally feasible exterior diameter;
- High mechanical strength characteristics – high rotation torque and elevated stretching stresses.

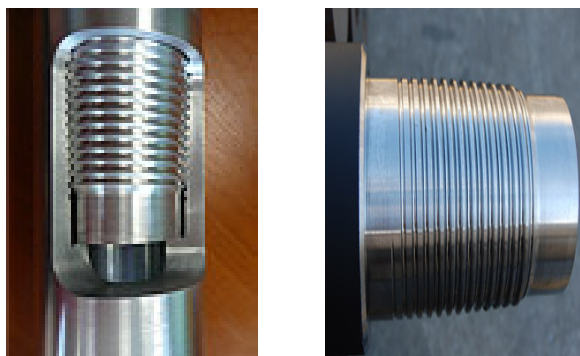


Fig. 1. Double shoulder joint types

One should give up using traditional drill pipes (31,5 feet = 9,60 m, Range 2) and start using drill piles 44,5 feet = 13,56 m long (Range 3). This approach enables us to reduce the total number of joints per total length of the drill string and reduce pressure losses in joints, respectively. Moreover, this approach enables us to reduce the weight of 1 average meter of the drill pile. Our specialists accounted for drilling conditions and well designs in most West and East Siberian hydrocarbon fields and in polar regional fields as well. They accounted for these conditions, working on comparative calculations assigned for a drill string, consisting of standard 127 mm drill pipes and for a drill string, consisting of 139,7 mm drill pipes equipped with double shoulder joints.

Table 1. Comparative weight of a drill string

Types of drill pipes	Length, meters	Type of joint	Weight of 1 average meter kg/m	Weight of drill string, tons
127 × 9,19 S-135, joints NC-50 Range 2	5000	NC 50	35,55	177,75
139,7 × 9,17 S-135, joints XT-57 Range 3	5000	XT57	36,79	183,95

Table 1 shows that weight of a drill string, composed by 139,7 mm drill pipes is practically equal to weight of a drill string, composed by 127 mm drill pipes. This phenomenon is pre-determined by following factors: use of Range 3 drill pipes instead of Range 2 pipes and by lighter weight of double shoulder joints opposite to heavier weight of standard joints.

Table 2. Losses of hydraulic pressure in kgf/cm<sup>2</sup> per 1000 m of drill pipes

Types of drill pipes	Interval	Ø of drill bit 393,7 mm		Ø of drill bit 295,3 mm		Ø of drill bit 215,9 mm	
		Q = 70 HP	Q = 60 HP	Q = 55 HP	Q = 45 HP	Q = 35 HP	Q = 30 HP
127 × 9,19 S-135 joints NC-50 or ZP -168-70	Pipes	58,34	44,20	37,79	26,34	16,75	12,69
	Joints	42,18	31,96	27,33	19,04	12,12	9,18
	<b>Totally</b>	<b>100,52</b>	<b>76,16</b>	<b>65,12</b>	<b>45,38</b>	<b>28,87</b>	<b>21,87</b>
	K.p. of OS	3,19	3,18	5,23	5,17	10,87	10,68
	OS joints	0,23	0,23	0,42	0,41	1,55	1,48
	<b>Totally OS</b>	<b>3,42</b>	<b>3,41</b>	<b>5,65</b>	<b>5,58</b>	<b>12,42</b>	<b>12,16</b>
	K.p. of OK	3,04	3,03	4,91	4,86	9,66	9,49
	OK joints	0,21	0,21	0,39	0,38	1,18	1,14
<b>Totally OK</b>	<b>3,25</b>	<b>3,24</b>	<b>5,3</b>	<b>5,24</b>	<b>10,84</b>	<b>10,63</b>	
139,7 × 9,17 S-135 joints XT-57	Pipes	34,94	26,47	22,64	15,77	10,04	7,60
	Joints	3,99	3,02	2,59	1,80	1,15	0,87
	<b>Totally</b>	<b>38,93</b>	<b>29,49</b>	<b>25,23</b>	<b>17,57</b>	<b>11,19</b>	<b>8,47</b>
	K.p. of OS	3,37	3,35	5,72	5,65	13,31	12,97
	OS joints	0,18	0,18	0,35	0,34	1,73	1,62
	<b>Totally OS</b>	<b>3,55</b>	<b>3,53</b>	<b>6,07</b>	<b>5,99</b>	<b>15,04</b>	<b>14,59</b>
	K.p. of OK	3,21	3,19	5,34	5,29	11,52	11,28
	OK joints	0,20	0,20	0,39	0,38	1,46	1,39
<b>Totally OK</b>	<b>3,41</b>	<b>3,39</b>	<b>5,73</b>	<b>5,67</b>	<b>12,98</b>	<b>12,67</b>	
<b>Ø 127</b>	<b>Totally</b>	<b>103,94</b>	<b>79,57</b>	<b>70,77</b>	<b>50,96</b>	<b>41,29</b>	<b>34,03</b>
<b>Ø 139,7</b>	<b>Totally</b>	<b>42,48</b>	<b>33,02</b>	<b>31,30</b>	<b>23,56</b>	<b>26,23</b>	<b>23,06</b>
ØIII 139,7 in % to Ø 127	Pipes	38,7	38,7	38,7	38,7	38,8	38,7
Ø 139,7 in % to Ø 127	K.p.	103,8	103,5	107,4	107,3	121,1	120,0
<b>Ø 139,7 in % to Ø 127</b>	<b>Totally</b>	<b>40,9</b>	<b>41,5</b>	<b>44,2</b>	<b>46,2</b>	<b>63,5</b>	<b>67,8</b>

Table 3. Comparative rigidity parameters of drill pipes

Type of drill pipes	EJ, kgf·m <sup>2</sup>	Ratio EJ
127,0 × 9,19	124 610	1,00
139,7 × 9,17	168 926	1,36

Table 3 demonstrates that rigidity of pipes 139,7 mm is by 36 % higher opposite to rigidity of 127,0 mm pipes.

Table 4. Upward flow velocity in m/sec in annular space

Type of pipes	Ø of drill bit 393,7 mm		Ø of drill bit 295,3 mm		Ø of drill bit 215,9 mm	
	Q = 70 HP	Q = 60 HP	Q = 55 HP	Q = 45 HP	Q = 35 HP	Q = 30 HP
127,0 × 9,19	0,64	0,55	0,99	0,81	1,46	1,25
139,7 × 9,17	0,66	0,56	1,03	0,85	1,64	1,41
Growth in %	2,5	2,6	5,0	5,0	12,5	12,5

Legend used in above Tables:

*127×9,19 S-135 joints NC-50 or ZP-168-70* – drill pipes with outer diameter equal to 127-mm, with wall thickness equal to 9,19-mm, grade S-135 , standard joints NC-50 or ZP -168-70;

*139,7×9,17 S-135 joints XT-57* – drill pipes with outer diameter equal to 127-mm, with wall thickness equal to 9,19-mm, grade S-135 , joints XT-57 (type of joints – double shoulder joints produced by “GrantPrideco” manufacturer);

*Pipes* – hydraulics resistivity in interior space of drill pipes;

*Joints* – hydraulics resistivity in interior space of joints of drill pipes;

*K.p. OS* – hydraulics resistivities in annular space between the body of drill pipes and well wall in open hole interval;

*OS joints* – hydraulics resistivities in annular space between joints of drill pipes and well wall in open hole interval;

*K.p. OK* – hydraulics resistivities in annular space between the body of drill pipes and well wall in cased hole interval (cased by previously landed casing string);

*OK joints* – hydraulics resistivities in annular space between joints of drill pipes and well wall within the interval of the well cased by previously landed casing string.

## Conclusions

One among the others major optimization ways of drilling processes refers to use of 139,7 mm drill pipes instead of 127,0 mm drill pipes. Use of new pipes enables us to exploit following advantages, itemized below:

1. Reduction of composite hydraulic pressure losses in pipes and in annular space by 30-60 %. In other words, one can increase the pressure, realized (applied) on the bit. This approach enables us to optimize drilling hydraulics – e.g. to increase hydraulics capacity applied on the bit and to increase hydraulics impact force. These measures will lead to further improvement of drilling parameters.

2. Endurance capacity of drill pipes along the body of pipes increases by 10 %.

3. In the threading of the “double shoulder” joint, applied stresses are equally distributed along the length of the thread joint. Hence, probability of hypothetical failures of set drill pipe pins substantially reduces during salvage operations.

4. Rigidity of 139,7 mm drill pipes is by 36 % higher as rigidity of 127 mm pipes. In other words, resistivity of these new pipes to sinusoidal and to spiral fracturing is higher by 36 %. It will offer following advantages:

– drilling of horizontal wells leads to expansion of the interval of possible drilling with screw downhole motor; hence, we reduce the drilling interval to be drilled with the rotary steerable system. Consequently, this approach enables us to reduce OPEX costs per drilling of one well;

– resistivity to fatigue is higher; we can increased rpm during drilling process accompanied by rotation of the drilling string (without and hazards within the zone, affected by fatigue stresses);

– we decrease meandering trajectory of the wellbore (micro bends); this measure enables us to mitigate hypothetical problems during landing of casing strings into the hole;

– landing of 168 mm liners into 245 mm string enables us to reduce hypothetical problems to be triggered by turnouts of drill string from the set liner in deep horizontal wells;

5. Velocity of upward flow in the annulus is higher; cutting transport parameters and borehole cleanout parameters turn better.

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