BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 4B/2010	29 - 34	Seria Tehnică

Bayonet Joint Opportunities for Using in Large Diameter Drill Stem Connections

Adrian Creiţaru

Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti 39, Ploieşti
e-mail: adrian_creitaru@yahoo.com

Abstract

In large diameter drilling domain the drill stem may use one of the following assembly types: thread shouldered, flanged or bayonet connection. Among these, first two kinds are often in practical use.
The bayonet joint, even if less known and used, has some certain advantages such as: fast operating, both rotary wise torque applying and a benefic working loads separation, on its own separate components.
The calculus particularities of bayonet connection are concerning the specificity and various stress approach lines for its parts as well the shape types related to technological solutions.

Key words: *large diameter drilling, drilling stem, bayonet connection*

Specific Features of the Large Diameter Descendant Drilling System

The large diameter descendant drilling system is alike the well-known oil and gas one and the drill-stem structure or operating mode are similar too. The main difference is in dimensional domain; regarding the pipe diametric and joint size, these are over usual dimensions.

This case, the drilling diameter is large or very large; usually, the well diameter can be on D_s=1.5...5m, but some countries had drilling programs even on larger diameters: D_s=7...8.75m [1], [4]. To achieve these drilling targets, the down-hole assembly had to be large and heavy, fact that induced special strength regulations for pipes and their joints.

The mud circulation to the down-hole drill bit can be processed by various ways, depending on diameter and depth borehole, type of the hole drilling program, mud rate or rock stratification. Currently, both systems of direct or inverse circulation are used in practice; moreover the drill bit injection is preferred. Same time, the airlift system proved its efficiency and now is frequently used.

Large Diameter Drill Stems Structure and Main Connections in Use

The large diameter drill stem has the same known usual structure: square kelly, drilling pipes, stabilizer-correctors, drill collar and bit body. These components are connected in one of the types:
- shouldered threaded (pin-box) joints;
- flanged joints;
- bayonet joints.

Yet, these first two mentioned types are most in use. The last one, even if brings such certain advantages, is insufficiently tested and adapted for drilling field conditions. That's why this type of connection is actually in limited use [1], [2], [4].

The Particularities of the Bayonet Connection

The choice for bayonet drill stem joints has been generated by the need to remove such disadvantages brought by the use of the threaded or flanged connections. Some of these specific disadvantages should render evident:

- Long standing to fit up the joint, particularly for the flanged assembly;
- Restriction for working both spin senses – especially, referring to the threaded joints;
- Susceptibility of threaded joint to high axial loading and the need of (re)screwing up;

In paper [2] there is a detailed comparative analyze of all kinds of drill stem connections, turned into theirs evaluation required in drill stem designing. Anyway, this problem can't be easy disjointed; to take the key of the problem always means a compromise with each other preliminary conditions.

The bayonet connection is a mechanical kind of assembly, specifically shaped; using mating profiles as spline-groove, to joint two pipes fix ends when drill stem has to fit up. This type of connection has to be shape adapted for high axial and torque loads, as large diameter drilling process always needs.

The bayonet has not a specific master profile. Constructive solutions are diversified by technological or process needs. In large diameter drilling, this bayonet joint solution was already accessed in USA, old USSR, China and Romania.

In figure 1 are shown two different assembly shapes for large diameter bayonet connection.

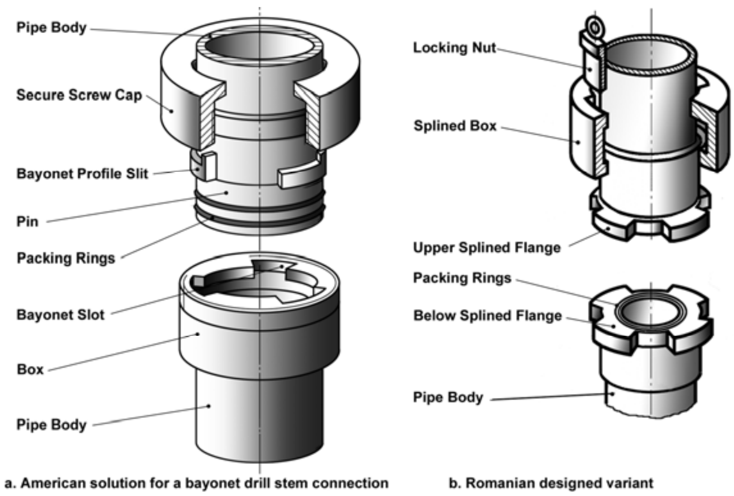


Fig. 1. Two bayonet joint solutions for large diameter drill stem connections

The constructive solution analyzed here (Fig. 1, *a*) is a variant size of D_n=14 $^3/_8$ inch, designed by IPCUP Bucharest. This drill pipes have fixed at both ends two splined flanges, each of them with 4 ruts. The splined box is hanging on upper flange to make possible the connection when fit up the stem. So, this splined box is an adapting piece joining up ends of the consecutive pipes. The splined box has also 4 ruts in the bottom side corresponding to the splined flange shape. The upper side has only 2 ruts, dedicated to the key joints for spin locking. The complete image of the assembly is brought by the two locking keys, in axial antipodal position to block body parts by the purpose of working torque transmission. All these parts are shown in figure 2.

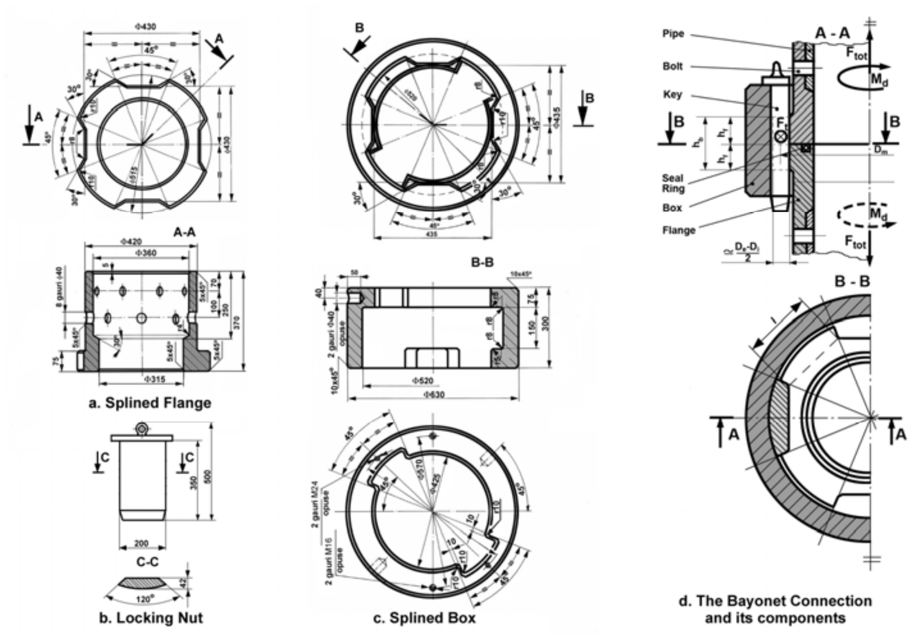


Fig. 2. The bayonet connection structure designed by IPCUP for the 14 $^3/_8$ inch drill stem assembly

The assembly mounting means to drag the splined box over the lower splined flange, then whirl on by 45^o till lapping them and locking joint by keys. This way, the fixed connection or the drill string becomes operational for drilling.

Advantages vs. Disadvantages Concerning the Bayonet Connection Use

The bayonet connection is also called *fast connection*, due to the reduced time to fix the joints. In many rig working situations this can be spotted as an important operative advantage. Extending this analyze, the main advantages of the bayonet connection use are as follows:
- The rapidity of operating time, meaning cumulative drilling time reduction;
- A high bearing capacity to specific stem loading;
- The rotary working torque can use both rotating sense;
- Load separation; tensional (axial) load and torsion load are to remove on such different assembly parts;
- There are not necessary special tools for jointing.

At the same time, there are some certain disadvantages to be marked:
- The complexity of joint shape, generating certain technological difficulties;
- There are a lot of precision restrictions involved in a good shape execution of the parts;
- The certain difficulty to provide the gasketing conditions for pipe connections.

Stress Calculation Particularities

The complex strain and stress stage of the stem and its bayonet connections

The strain and stress calculus management starts from the global load system of the large diameter drill stem. In different operative moments (stages), there are different aspects of load distribution. In these conditions, the special weight of the drill stem, (G_{tot}), plays a very prominent part, more significant than for the usual drill stem.

A dedicated study in paper [1] – for the drill stem size 14 $^3/_8$ inch – shows that a significant part of the entire weight amounts to the down-hole heavy assembly. As the Table 1 shows, the down-hole assembly weight means among 41.6 to 83.1% of whole weight load, depending on maximum drilling depth.

Table 1. Specific weights of the drill stem size 14 $^3/_8$ inch, for well depth of H_{max} = 100…650m

Weights \ Conditions	Drilling well depth conditions, H_{max}, [m]						
	100	200	300	400	500	600	650
Heavy assembly weight, G_h, [x10^3N]	G_h=G_b+G_{st}+G_{dc}=1605=ct						
Drill pipes string weight, G_{tot}, [x10^3N]	325	685	1025	1365	1705	2045	2255
Total stem weight, G_{tot}, [x10^3N]	1930	2290	2630	2970	3310	3650	3860
Weight ratio, [%]	83.2	70.1	61.0	54.0	48.5	44.0	41.6

The total weight determined by this cumulative calculus becomes maximum axial load for one of the critical load cases: *Case I – trip round* means operations to trip in or to trip out procedures, in absence of torque (Fig. 3, *a*). Here, a few clarifications is required: this case, the most loaded connection is situated at the uppermost position (joint *n*), there are involved only weight forces and the drill stem length has to be maximum hole-depth.

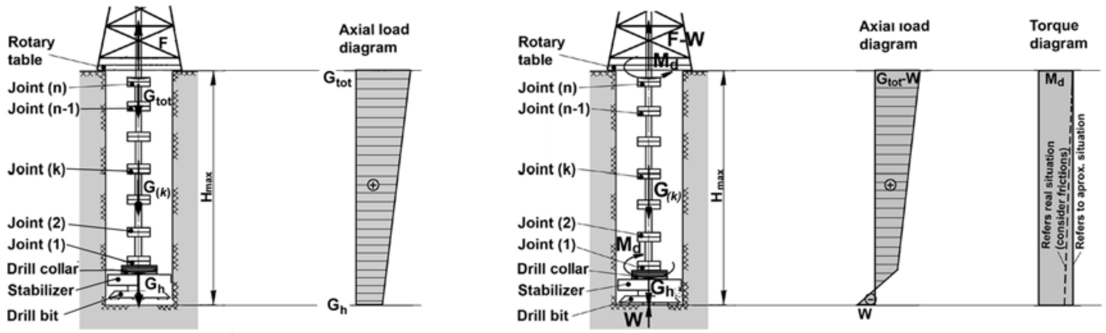


Fig. 3. Calculus diagrams for the most critical cases for the drill stem loading

The Case II of the stem load can be defined when drilling operation begins, for the maximum hole depth (fig. 3, *b*). This case, the drill stem and its joints are in a composite strain stage: axial tension (higher for joint *n*), G_{tot}–W (W – bit thrust) and running torque, M_d. This torsion load gets maximum level over the upper string zone (for joint *n*) at the mouth of the bore.

The running torque, M_d, is a fluctuating load through shaft drilling. Most of all, it depends on following three parameters:

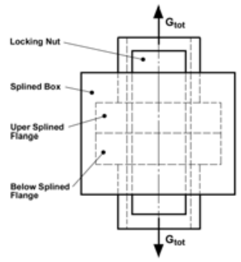
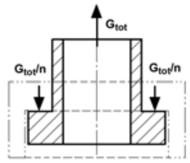
- Drilling hole diameter, D_b;
- Bit thrust (also variable by strata conditions), W;
- *Drillability factor*, K, which depends on rock hardness.

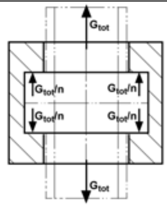
Specific strain induced on assembly components

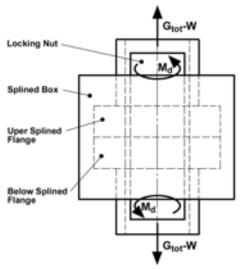
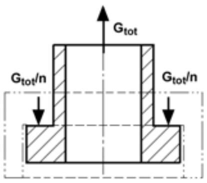
The strain stage developed on drill stem and also on string joints differently determines the load of their integrant parts. It involves some other load and strain in terms of joint components (which are different by those mentioned above).

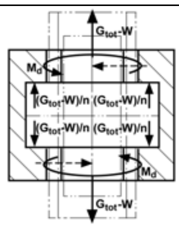
In order to highlight these aspects concerning loads, strain and stress analyze – applied to joint and its parts – we propose the suggestive approach in Table 2. This way, the composite strain for each bayonet component can be exhaustive discerned.

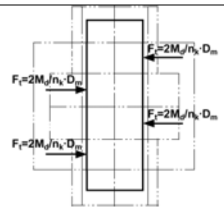
Table 2. The main aspects over strain and stress calculus of the bayonet connection

<table>
<tr><th>The strain stage concerning the stem and its connections</th><th>The load scheme for the bayonet connection</th><th>The load distribution over the joint components</th><th>The composite strain determined over the components</th></tr>
<tr><td rowspan="8">Case I
Tensional Load (weight provenance)</td><td rowspan="8">
</td><td rowspan="4">

Splined Flange</td><td>Axial tension on tubular zone, σ_t</td></tr>
<tr><td>Spline (groove) shearing, τ_f</td></tr>
<tr><td>Frontal Spline compression pressure, p</td></tr>
<tr><td>Spline bending, σ_i</td></tr>
<tr><td rowspan="4">

Splined Box</td><td>Axial tension on tubular zone, σ_t</td></tr>
<tr><td>Shearing of shoulders, τ_f</td></tr>
<tr><td>Frontal Spline compression pressure, p</td></tr>
<tr><td>Spline bending, σ_i</td></tr>
<tr><td rowspan="13">Case II
Tensional and Torque Load (weight and drilling provenance)</td><td rowspan="13">
</td><td rowspan="5">

Splined Flange</td><td>Axial tension on tubular zone, σ_t</td></tr>
<tr><td>Torsion on tubular and groove zone, τ_t</td></tr>
<tr><td>Spline (groove) shearing, τ_f</td></tr>
<tr><td>Frontal Spline compression pressure, p</td></tr>
<tr><td>Spline bending, σ_i</td></tr>
<tr><td rowspan="5">

Splined Box</td><td>Axial tension on tubular zone, σ_t</td></tr>
<tr><td>Torsion on tubular and groove zone, τ_t</td></tr>
<tr><td>Shearing of shoulders, τ_f</td></tr>
<tr><td>Frontal Spline compression pressure, p</td></tr>
<tr><td>Spline bending, σ_i</td></tr>
<tr><td rowspan="3">

Key</td><td>Keys shearing, τ_f</td></tr>
<tr><td>Compression pressure on the side zone of the keys, p</td></tr>
<tr><td>Keys bending, σ_i</td></tr>
</table>

The stress and strain perspectives for complex analyze. Stress concentrating

The applicative calculus achievement in sense to establish the resulting stress – always necessary when verifying the assembly components – is not the subject of this paper approach, caused by the great volume of calculation. However, for relevance, there is useful to present some selected results comprised in study [1].

This tackle, achieved for the 14 $^3/_8$ in drill stem, considered the tensile and torque critical (maximal) load determination, for both mentioned cases. The determined values of maximal load were: by the compression resistance criterion for splined flange-box: $F_{cap,c} = G_{tot} = 4.365 \cdot 10^3$ kN; by the shearing criterion for splines: $F_{cap,sh} = G_{tot} = 10.132 \cdot 10^3$ kN; by the bending criterion for flanges and box splines: $F_{cap,b} = G_{tot} = 11.257 \cdot 10^3$ kN. It's obvious resulted that, in this case, the *compression pressure criteria is the most restrictive*, bringing the bearing tensile capacity: $F_{cap,c} = 4.365 \cdot 10^3$ kN > hook maximum load of 400 tf.

The torque bearing capacity determination considered the two keys contact pressure and shearing resistance condition; $M_{d,cap} = 797 \cdot 10^3$ N·m shows a high enough redundant torsion load ($M_{d,cap} >> M_{t,max} = 200 \cdot 10^3$ N · m – as the maximal torque limit of the drill unit in use).

The complex shape of both splined box and flanges has a lot of specific zones, richly featuring shape and dimensions. Certainly, these are the meaning stress concentrator areas.

The analytical stress concentrator determination becomes hard and difficult devoid of specific stress concentration factors dependent on dedicated shape or load event. Therefore, approaching the FEM analyze – possibly by interactive tackle – could be a better solution.

Conclusions

- This kind of joint brings a couple of functional advantages: the most important refers to rapidity of fitting and two way rotary drill working.
- The complex strain stage, for both critical load cases, determines a spatial stress stage that induces a series of inconveniences in resistance verification of the components; an advisable line should be the complete structure modeling, followed by FEM procedure.
- The FEM approaching can bring moreover a detailed stress and strain representation which becomes very helpful in global stem strain condition, also in available stress higher points, mean to diminish them.
- Using bayonet connection in field practice requires finding such better and more efficient sealing solutions instead without technological complications of the joint.

References

1. C r e i ţ a r u , A. - *Contribuţii la studiul asamblărilor garniturilor utilizate în forajul de diametre mari*, Teză de doctorat, UPG Ploieşti, 2004
2. C r e i ţ a r u , A., Raşeev, D. – Analiza comparativă a variantelor constructive de asamblări pentru garnitura de foraj minier în sistem descendent, *Construcţia de maşini*, Nr. 5-6, Anul LVI, Bucureşti, 2004.
3. C r e i ţ a r u A . – Considerations over the determination of carrying capacity for the bayonet drill pipe connections, *Sesiunea Anuală Internaţională de Comunicări Ştiinţifice IMT*, Oradea, 2007.
4. I o r d a c h e , G h . s. a. – *Forarea sondelor cu diametre mari*, Editura Tehnică, Bucureşti, 1983.

Oportunităţi ale asamblărilor cu şliţuri folosite în construcţia garniturii de foraj de diametre mari

Rezumat

În forajul de diametre mari, pentru garnitura de foraj se pot folosi următoarele tipuri de asamblări ale componentelor: filetate cu umăr, cu flanşe sau cu şliţuri. Între acestea, primele două au fost utilizate în mod sistematic.

Asamblarea cu şliţuri, mai puţin cunoscută şi folosită la asamblarea elementelor garniturii, prezintă câteva avantaje certe: rapiditatea manevrei, posibilitatea utilizării în ambele sensuri de rotaţie cât şi separarea încărcărilor principale (de lucru), pe elemente distincte ale acesteia.

Particularităţile calculului acestor îmbinări sunt date de specificul şi diferenţierile de solicitare ale componentelor ca şi de variantele de formă impuse de soluţiile constructive.