RISER SYSTEMS FOR ECONOMIC DEEPWATER WELL INTERVENTION

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INTRODUCTION

Floating production with subsea completions is currently acknowledged as the favoured technology for development of marginal and deepwater reserves. It is a technology that has been in existence for over 10 years but has only recently been widely adopted in favour of more technologically complex systems such as TLPs and SPARs which facilitate surface completions.

Floating production with subsea completions offer a number of key advantages such as a fast track schedule, low CAPEX to first oil and phased development. In the current economic climate these factors are an essential factor in maximising the NPV of an asset allowing project status to be achieved. Additionally, floating production is seen as a low risk solution, since the technology is well proven and can accommodate design changes without severe impact and is flexible to meet the completion and drilling requirements of a wide range of reservoir configurations.

Unfortunately nothing is usually perfect and there is normally a down side. For floating production, the down side is primarily the high through life cost of well intervention and workover operations. Unlike the TLP and SPAR where well intervention can be conducted directly from the production facility, subsea completions require mobilisation of a rig to conduct workover of subsea step out wells. This method of workover is costly, due to high rig rates and long mob/demob durations, particularly if the intervention is unplanned. Future workover costs will increase, due to the increase in rig rates which is predicted over the next decade, particularly in deep water and also as developments move into harsh environments which increases intervention durations and complexities. This may have a dramatic effect on the economics of existing subsea developments which may have been justified on the basis of lower rig rates.

OBJECTIVE

The industry objective must be to reduce intervention costs without losing the important benefits that floating production offers. Four possibilities are identified to achieve this aim:

a) Improve completion reliability
b) Configure field layout to allow simultaneous drilling/workover and production
c) Develop more efficient practices for intervention
d) Identify new methods for direct well intervention from the FPS

These possibilities are discussed in the following sections.

COMPLETION RELIABILITY

Higher levels of completion reliability reduce the need to re-enter the well and has been an ongoing aim of the industry for many years. As a result the reliability of completions has been improved through use of better designed hardware, new materials, revised installation techniques and better understanding of reservoir issues. Workovers due to equipment failures have been dramatically reduced however, workovers to maximise productivity is largely determined by reservoir issues.

SIMULTANEOUS DRILLING WORKOVER AND PRODUCTION

The cost of workover can be greatly reduced if the wells are located directly below the production vessel. This allows drilling and workover to be conducted without the need to mobilise a separate vessel. The wells may be tied back to the production vessel using a range of different production riser configurations including flexible, steel catenary or hybrid. These systems can be configured to allow simultaneous installation of either a drilling riser or completion riser onto the subsea wells.

Whilst this configuration appears to solve the problem of high workover costs and allows development drilling from the production vessel, it has a number of disadvantages.

- Requires the use of a production semi-submersible (unless conditions are very mild)
- Higher CAPEX than an FPSO with step out wells
- Clustered wells require directional drilling to reach extents of reservoir
- Generally not suitable for shallow reservoirs

The effect of these issues, particularly the directional drilling requirements, means that such an arrangement is currently best suited to developments where the reservoir has a small extent and/or where workovers are predicted to be frequent and thus justify the higher CAPEX and drilling costs. However, as rig rates increase, this configuration may become more favourable. Such a system would need to export via a pipeline to existing infrastructure or off-loading buoy.

EFFICIENT SUBSEA WELL INTERVENTION

The normal practice for subsea well intervention is to mobilise a drilling semi which is costly and time consuming due to the high rig rate and lengthy mobilisation/transit times. In addition, once at site the semi must lay a mooring spread which is often complicated by the proximity of subsea flowlines, risers and the production vessel mooring pattern.

Once at the well site the semi performs well intervention using either the drilling riser or completion riser. Both risers and particularly the completion riser are time consuming to install due to the nature of their design. In deeper water this problem is exacerbated and improved completion riser designs are required not only for deep water but also for the harsh environments, such as the West of Shetland, where weather windows for running and retrieval are short.

For major workovers, where full wellbore access is required, there is currently no alternative to the use of a drilling semi as it is necessary to employ a full bore (18-3/4 inch) subsea BOP stack. However, where access is only required to the production tubing, ie. a minor workover, the use of a drilling riser and BOP is unnecessary. In these cases the intervention equipment is significantly lighter than for major workover and it is feasible to considerd installation from a DSV or MSV.

Subsea wirelining from a DSV is now relatively common practice. A subsea lubricator and BOP is installed on top of the subsea completion and wireline is run in open water to the DSV. Note this arrangement is different to wirelining from a semi where the wireline is run inside a high pressure completion riser with a surface lubricator.

Unfortunately the tasks that can be performed with wireline is limited due to the strength of the wireline and inability to circulate. Conversely coiled tubing has a much higher axial load capacity and provides the facility to circulate allowing a much wider range of downhole tasks to be conducted. It is for these reasons that coiled tubing has gained such popularity in recent years as its benefits have become more apparent. Workovers are now performed using coiled tube that would previously have required a major workover, saving numerous rig days.

The use of coiled tubing deployed from a DSV or MSV offers a low cost and flexible means of performing well intervention. The DSV can be mobilised more quickly than a semi and by virtue of its dynamic positioning capability eliminates the problems and expense associated with anchor handling. The disadvantage of using a DSV or MSV compared to a semi is its worse motion characteristics leading to a smaller operating weather window. However, with correct design and system optimisation of the riser system operating window acceptable weather windows can be achieved.

The riser arrangements considered for well intervention to-date rely on a vertically tensioned high pressure monobore intervention riser. This can be installed with conventional tooling quicker than a 5x2 completion riser with time savings of over 50%. Annulus access is provided through a control umbilical which is strapped to the outside diameter of the riser.

At the surface the riser passes through the DSV moonpool and into a workover derrick where the coiled tubing injection head assembly is located. The layout of the derrick and riser interface is important as vessel motions can be large, particularly heave, pitch and roll. The derrick and moonpool size is generally limited and the coiled tubing injection head assembly is large. The riser arrangement and vessel interface must therefore be developed to address the following important design issues:

- Derrick space out
- Vessel motions and riser stresses
- Coiled tubing stresses and fatigue
- Tensioner characteristic and failure modes
- Vessel DP positioning
- Moonpool clearance
- Riser fatigue and VIV
- Base and tree loading
- Emergency disconnect
- Subsea control interface

At the base of the riser a conventional EDP and BOP assembly is required, complete with taper joint to limit riser stresses. Particular emphasis must be placed on the design and specification of the EDP since this must able to operate quickly and under high load in the event of a drive off situation. The design of a weak link may also be prudent as an additional precaution to prevent damage to the completion.

An alternative to the vertically tensioned riser is the use of a steep wave steel catenary. This arrangement is particularly suited to deep water applications and has a number of advantages over the vertically tensioned arrangement the most important being a simplification of the derrick interface. This is achieved by virtue of using a static coiled tubing unit ie. The riser is not motion compensated but fixed relative to the vessel. The riser configuration, which uses external buoyancy is designed to be compliant to accommodate the vessel motions without motion compensation. The fixed coiled tubing unit has the added benefit of limiting dynamic coiled tubing stresses in the section between the storage reel and bend restrictor.

In conclusion, and based on work completed to date, it is shown to be feasible to run a vertically tensioned intervention riser from a DSV in a wide range of water depths up to 1000m and in an environment typical of the North Sea achieve good weather windows and operability. This saves costs over use of a conventional semi. Further developments of the riser configuration may allow the operability to be further improved particularly for deeper water applications. We predict that this technology will see increasing application in future years as the demand for deep water rigs increases.

DIRECT WELL INTERVENTION FROM THE FPS

The technology described in the preceding sections does little more than extend existing practices to cheaper and more convenient vessels. Generally such intervention techniques will not require significant modification to the way in which subsea equipment is currently designed and configured. Whilst it offers cost reductions it is not a perfect solution and still falls well short of the intervention capability offered by TLPs and SPARs for the following reasons:

- The operator is still reliant on vessel availability
- There are currently few vessels capable of running an intervention riser
- The time taken to mobilise may result in lost production

The perfect solution would allow workover operations to be performed on step out wells directly from the floating production facility and it is believed that this may be feasible in the future. Two possible solutions are postulated.

Steep Wave Steel Catenary

In deep water a steep wave or dog leg steel catenary may be employed to provide direct vertical access into a wellbore. In water depths of 800-2000m horizontal step out distances of between 1km and 3km may be achieved giving a diametrical reservoir coverage of up to 6km. Workover is achieved using coiled tubing which would readily traverse the riser section into the completion via either a vertical access or Y spool. Major workovers would be conducted using a DP semi positioned directly overhead with sufficient clearance from the production facility.

This arrangement would allow a wide range of well intervention without the need to mobilise a workover vessel. This would allow optimum reservoir management and improved productivity.

Lazy Wave Steel Catenary

For developments in shallower water and/or which need to use step out wells with a longer step out distance than above the use of TFL technology may be re-considered through lazy wave steel catenary riser systems. TFL tools are pumped down the flowline directly into the wellbore and then back via a return line. Whilst this technology has been around for many years it has not been widely adopted due to the complexity of the system and limited tasks that can be completed with the current tools. However there is a possibility of combining the pumpdown tool concept with coiled tubing to allow the following benefits:

- Circulation
- Retrieval of tool on coiled tubing
- Supply of power (hydraulic and electric) to down hole tools

Whilst this is very much a forward looking concept the advantages it offers in providing direct well access from the production vessel seem to be a valuable goal. The disadvantage of such an arrangement is that it requires a single riser to each tree or subsea selector technology. Additionally the coiled tubing drag forces along the horizontal sections of the riser will need to be overcome. However, this problem is similar to the problems already encountered and solved in horizontal and highly deviated wells. Coiled tubing tractor devices, hydraulic pressure and high pressure circulation should allow these problems to be overcome.

CONCLUSION

Subsea completions and floating production technology is widely predicted to be the technology for development of future deepwater reserves.

Significant cost reductions can be achieved through the use of more efficient well intervention techniques allowing through life costs to be reduced.

Coiled tubing deployed from monohull vessels is expected to be an important method of reducing intervention durations and reliance on drilling vessels.

Current studies confirm the feasibility of deploying coiled tubing using existing equipment and proven procedures. Practical weather window are shown to be achievable.

Direct well bore access from the production vessel is a future target and TFL may once again be reconsidered if rig day rates increase as predicted. Developments of TFL and coiled tubing technologies deployed through low cost steel catenary risers may offer significant technical and commercial benefits.

REFERENCES

(1) ‘Rigid Riser Systems for Economic Deepwater Well Intervention’ by Stephen Hatton and Dr Shan Huang, 2H Offshore Engineering Limited, DEEPTEC 96, Aberdeen.