DESIGNING AND EVALUATING A CASING PROGRAMFOR PETROLEUM WELLBORES

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Abstract: Due to high operational and financial risks associated with the investments in the petroleum industry, all precautions are taken by the operators to achieve a safe and cost effective well completion. Casing design of a drilling program is a critical element which contributes greatly to safety and cost of the operation. The objective of this research was to develop a casing design program which enables the user to evaluate casing design proposed or implemented in a drilling campaign. The developed casing design program consists of sequential criteria to select casing setting depth and establish optimum casing strength. Knowledge on local pore pressure gradient and facture gradient are essential to select the casing setting depths. Since both the factors are regional stratigraphy dependants, casing setting depth selection was designed in the way it allows user to assign variables for these parameters. Developed casing design program was validated with the casing design done by Rahman, S. S and Chilingar, G. V(1995). Validation results shows that the casing design of Rahman and Chilingar and the casing design done with the use of developed program are having similar casing setting depths except in the case of conductor casing.

Keywords: Burst, Casing, Collapse, Strength, Tension

1. Introduction

Objective of a drilling program in the petroleum industry would be either to explore and appraise possible reserves identified in a frontier basin to develop a new field or expand a producing field. Although drilling activities are planned with the use of exploration data, they can be encountered with unpredicted hazards while drilling. Casing design is one of the most critical part of a well plan as it ensures the safety of entire drilling operation. Normally casing design consists of five casing types, Conductor, surface casing, Intermediate casings, production casing and liners. Each type has

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unique well completion requirements.

Well planning and drilling program design are done by the operator while responsible regulatory authority of the country is reviewing and approving the same in the current upstream petroleum operations context. The approval is sharing Health Safety and Environment responsibilities of the operation among operator and the regulatory authority. In Sri Lankan context, Petroleum Resource Development Secretariat (PRDS) is the responsible authority empowered by the law to review and approve the drilling programs executed in offshore Sri Lanka.

The objective of this research was to develop a casing design program which has the capability to evaluate any well completion plan proposed by an operator as a part of a drilling program, which will be useful for PRDS in its future Sri Lankan operations.

2. Methodology

The casing design Progra developed during the research f well planning & evaluation consis of two designing stages. Provisic for Casing Setting Depths (CSI selection for each type of casi included at the initial designi stage. Casing strength requiremen are calculated in the next stage to select the optimum grade among the available casing grades in the industry.

2.1. Casing Setting depth selection

Selection of the Casing Setting Depths in the casing design Program was done based on the regional stratigraphy dependants; pore pressure gradient, facture gradient and Poisson's ratio of the formation. Since these factors are vary with the location, the Casing Setting Depth (CSD) selection criterion was designed in the way it allows user to assign variables for these parameters

2.1.1 Conductor casing shoe point selection

A graph of depth vs. mud fluid pressure was drawn starting from the rotary table height. Hydrostatic pressure line was drawn starting from the mean sea level and the overburden pressure was drawn starting from the Sea bed level on the same graph (shown in Figure 01). The depth where overburden pressure line and mud fluid pressure line intersect is selected as the conductor casing shoe depth.

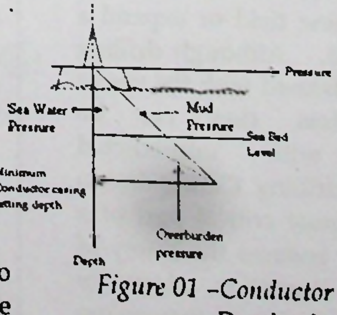

Figure 01 –Conductor Casing Setting Depth selection

2.1.2 Intermediate, Liners and Production Casings shoe point selection

A graph of pore pressure gradient Vs depth was drawn. Variation of mud gradient, fracture gradient and Kick margin (Kick margin is considered as a safety margin and it can be calculated by reducing 0.5ppg from the fracture gradient) with the depth were potted on the same graph.

From the bottom point of the mud gradient curve, a vertical line was drawn till it intersects the Kick margin and depth correspondent to that point is taken as the Casing Setting Depth for the production casing. Then a horizontal line was drawn from that point to mud gradient and a vertical line was drawn from this intersection point to the kick margin. The depth correspondent to this second intersection point is considered as the Casing Setting Depth of next casing or the liner. This procedure was repeated until the vertical line extension drawn without intersecting the fracture gradient graph.Then the casing string was validated for possible kick tolerances.

2.1. Casing String Design

Casing string design is addressing basic forces which the casing is undergoing; collapse, burst, tension and bi-axial effect. Mian, M.A.(1992)

2.2.1 Collapse criterion

Collapse pressure was calculated using the equation (1);

$$\textbf{Collapse pressure} = \textbf{Ext. pressure} - \textbf{Int. pressure} \qquad (1)$$

The casing is treated as a hollow pipe for the designing purpose and pressure inside the casing is taken as zero.

External pressure is originated by the drilling mud which used to run the casing and it was considered the situation where there is no cementing outside the casing. The collapse criterion can be illustrated as

$$\textit{Collapse Pressure} = \textit{Mud density} \times \textit{depth} \times g \qquad (2)$$

Where,

$$g = \textit{Gravitational Acceleration}$$

2.2.2 Burst Criterion

Burst pressure forms due to maximum formation pressure anticipated during the drilling of next borehole section. For the calculation, it was assumed that the external pressure on the casing is zero at the top of the casing and will increase with the depth.

$$\textbf{Burst pressure} = \textbf{Int. pressure} - \textbf{Ext. pressure} \qquad (3)$$

2.2.3 Tension criterion

Tension force acts on casing is due to its own weight, bending forces and shock loads. Upmost joint in the casing is considered as the weakest in tension as it carries the total weight of the string below it.

2.2.4 Biaxial Effect

The combination of stresses due to the weight of the casing and external pressures are referred as biaxial stresses. All casing strings were verified for falling in to the collapse region in the graph.

After calculating collapse and burst pressures, safety factors (or design factors) were taken in to account. Following safety factors were assumed for the calculations in the casing design program.

Burst = 1.1 - 1.125

Collapse = 0.85 - 1.125

Tension = 1.6 - 1.8

Plotting the variation of burst values and collapse values against depth on a same graph and verifying each available casing grade with the collapse and burst value is the final step of the casing design program as shown in the Figure 02.

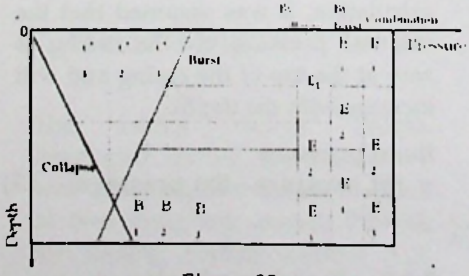

Figure 02 –

Strength parameters of available casings

4. Results and Validation of the criteria

After developing the designing and evaluation criteria a computer program was developed with the use of Microsoft Excel.

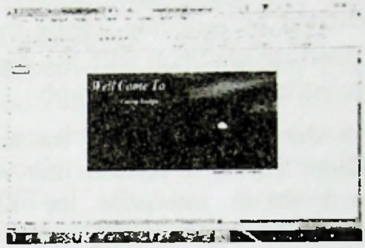

Figure 03 –

Interface of the designed program

Developed design & evaluation criteria was validated with the casing design done by Rahman, S. S and Chilingar, G. V(1995). It shows that the Casing program of Rahman and Chilingar and the casing design output given by the developed criteria have similar casing setting depth except in the case of conductor casing.

Type of casing	Casing depth /m	
	S.S Rahman's design	Output of the programme
Conductor	350	988.46
Surface	5000	5000
Intermediate	11100	11200
Liner	14000	14066
Production	19000	19000

Table 1 - Results of the validation

5. Conclusions

Casing design for an exploratory, development or production well should be done considering regional stratigraphy and in par with the standards in the petroleum industry. A methodology combined with Casing Setting Depth selection and casing strength calculation was derived and validated with the existing well data as a Casing Design Program. The aforesaid Casing Design Program is equipped with regional stratigraphy dependants as variables hence most suitable casing design for any region could be achieved by feeding relevant and accurate data for pore pressure gradient, fracture pressure gradient and poisons' ratio of the region.

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