**Probabilistic Approach to Casing Design using Monte Carlo Simulation**

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***Abstract*-**Casing Design plays an important role in the successful drilling of a well and accounts for a substantial percentage of well costs. The goal of casing design is to get an optimal design that will withstand the stress and other factors that affect the casing throughout the lifetime of the well. The conventional approach to casing design uses a deterministic working stress design (WSD), where minimum strength requirements of the casing are determined by comparing casing strength to the magnitude of severe accidental loads that may occur during the lifetime of the well. Uncertainties in the load and strength of the casing are accounted for by multipliers called safety factors (SFs) that are mostly based on experience and do not reflect the probability or consequence of the different casing failure modes. This approach may result in overly conservative casing designs, or design requirements for severe conditions that are expensive, leading to higher well costs.

In this paper, the MCS method is applied to casing design, where uncertainties in loads are considered explicitly by assigning probability distributions to uncertain parameters that affect stresses and material strength. As the MSC method predicts the failure probability, it gives a better view of the real risk involved in the design. Acceptable probabilities of failure can be selected based on the cost and consequence of an anticipated failure; thus, a stochastic-based design is more flexible as it allows more risk-consistent designs compared to traditional working stress designs.

***Keywords*** – Casing Design, Probability Distribution Function, Monte Carlo Simulation, Cumulative Density Function, Statistical Analysis

* 1. INTRODUCTION

Casing is the major structural component of a well. Casing is needed to maintain borehole stability, prevent contamination of water sands, isolate water from producing formations, and control well pressures during drilling, production, and workover operations [1]. Designing of casing string calls for knowledge of the operating conditions to be imposed on the casing as well as the concepts related to pipe properties [2]. under design casings are prone to failure at their early stage of operation. The overdesigned casing system adds higher cost to the total project expense [3]. Therefore, optimization of the casing design is essential to keep the casing cost minimal and the casing functioning properly.

The conventional approach to casing design uses a deterministic working stress design (WSD), which is based on multipliers called safety factors (SFs) [4]. The primary role of a safety factor is to account for uncertainties in the design variables and parameters, primarily the load effect and the strength or resistance of the structure. The magnitude of the SF is usually based on experience. Different companies use different acceptable SFs for their casing design presented in the relevant guidelines and recommendations, such as American Petroleum Institutes (API). While based on experience, SFs give little indication of the probability of failure of a given structure, as they do not explicitly consider the randomness of the design variables and parameters. Some other limitations of this approach are listed in [4].

Real world problems involve uncertainties [5]. In order to face engineering problems under uncertainty, it is necessary to prearrange proper probabilistic models capable of providing the quantification of such uncertainty, so that it can be taken into account in the process of decision making for engineering planning and design [6].

Several studies on the probability approach to casing design have been published. [7] found that material yield limit is the most inﬂuential random variable in the achieved failure probability, followed far by the wall thickness. The casing grade was also found to provide signiﬁcantly impact in the serviceability limit state. Some high failure probability values are noticed in K55 steel grade. [8] examined the probabilistic forecast workflow for WSD key output "Minimum Absolute Safety Factor". Using Monte-Carlo random sampling method, [9] obtained a probability of casing failure with different pressure and a relationship between safety factor and probability of casing failure. It was shown that casings of different types and under the effect of different external loads have similar safety coefficient and different probabilities of failure.

The objective of this paper is to comparatively study different probability distributions to determine the design load statistical values, with a Monte Carlo Simulation methodology applied for the selection of the most appropriate safety factor. Two probability distributions models are simulated using C# programming language. Distributions used in the analysis are Uniform and Triangular probability distribution models.

* 1. MONTE CARLO SIMULATION

# Random Number Generation.

# Selection of Appropriate Probability Density Function

* 1. PROBABILITY DISTRIBUTIONSOF RISER RESPONSES

Some text goes here

* 1. *Continuous Uniform (Rectangular) Distribution*
  2. *Triangular Distribution*
  3. APPLICATION OF MONTE CARLO SIMULATION TO CASING DESIGN

Some text goes here:

* 1. CASE STUDY DATA

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* 1. RESULTS AND DISCUSSION

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* 1. SUMMARY AND CONCLUSION

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