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Optimizing Completions in Deviated and Extended Reach Wells

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Abstract:

Optimizing completions in deviated and extended reach wells is a key to safe drilling and optimum production, particularly in complex terrain and formations. This work summarizes the systematic methodology and engineering process employed to identify and refine the highly effective completions solution used in ERW completion system and install highly productive and robust hard wares in horizontal and Extended Reach Wells for Oil and Gas. A case study of an offshore project was presented and discussed. The unique completion design, pre-project evaluation and the integrated effort undertaken to firstly, minimize completion and formation damage. Secondly, maximize gravel placement and sand control method .Thirdly, to maximize filter cake removal efficiencies. The importance of completions technologies was identified and a robust tool was developed .More importantly, the ways of deploying these tools to achieve optimal performance in ERW's completions was done. The application of the whole system will allow existing constraints to be challenged and overcome successfully; these achievements was possible, by applying sound practical engineering principle and continuous optimization, with respect to the rig and environmental limitation space and rig capacity.

Keywords: ***Well Completions , Deviated and Extended Rearch Wells , Optimization***

I. INTRODUCTION

. Well completion" is a means of installing hard ware and equipments in the well, to allow a safe and controlled flow of hydrocarbon from the well, or it is also said to be a series of activities to prepare an oil or gas well ready to produce hydrocarbon to the surface in a safe and controlled manner. (Hylkema *et al*, 2003).

Extended Reach Wells are wells that exceeded some step-out/vertical depth ratio 2:1. However, for most highly deviated wells in deep water environment, this definition does not fit. Some method has evolved to categories wells according to their step out within different vertical depth ranges. (Brady, *et al*, 2000). ERD wells then can be described conveniently as shallow, intermediate deep and ultra deep. Other variants are associated with operating in deep water and high pressure and high temperature environment. Currently there is no generally accepted ERW well deformation the current limitation for ERWs and UDWs is approximately 40,000st MD. Maersk oil currently has the longest shallow ERW. Exxon Mobil has the longest intermediate ERW and GNPP Nedra has the longest UDWs.(Sonowal, et al, 2009).

II.WELL COMPLETIONS

The selection of which system to use is depends on many factors. Firstly,whether the well is to be a producer or an injector. Oil, gas and water can be produced; including;water, steam and waste products - such as carbon dioxide and sulphur - can be injected. More than one purpose can be present, and the number of possibilities is thus large.

Completions are often split into two groups namely;

(1) Reservoir or lower completion

(2) Upper completion.

The lower completion is the connection between the reservoir and the well. The upper completion is the conduit from reservoir completion to surface facilities. The major decisions that needs to be made in regards to reservoir completion are namely ; open hole versus cased hole, sand control requirement and type of sand control, stimulation and single or multi-zone. Choices for upper completions; artificial lift and type, tubing size, single or dual completion and tubing isolation, packer or equivalent (Fitnawan, *et al* 2009).

III. LOWER SECTION COMPLETION OPTIMIZATION OF WELL UNIPORT U-XXX

The lower completion optimization design was quite straight forward. It was agreed to run the 6'' BHA along with the bit and scrapper. Installation of the Reglink Screen Assy follows up immediately before setting the CompSET packer II. In order to ensure the reliability of the CompSET packer II in terms of its designed functionality, it was determined that CompSET packer II be tested before cleaning the wellbore. An overall designed process flow diagram of this process is attached on Appendix B.

IV. UPPER SECTION COMPLETION OPTIMIZATION OF WELL UNIPORT U-XXX

For the upper completion the process flow diagram was quite complicated. First, based on the horizontal hole profile; it was agreed to wear bushings and wear head watch before the deployment of the $3\frac{1}{2}''$ upper completion string. This is immediately followed by spacing out completion string before it is landed and pressure tested on position to ensure its integrity. If it passes the test, then the BOP must be removed from the wellhead order wise the completion string must be spaced out, re run and tested. After the BOP has been removed, the Xmas must be run, tested and secured in position in order to ensure the well integrity, once completion process is achieved. Similarly an overall designed process flow diagram of this process is attached on Appendix D. In order to fully understand the theoretical aspect of this developed proposed optimized horizontal well completion plan, a mathematic model was developed to function as a real time diagnostic tool on site. This is detailed in the following section.

V. COMPUTER (SOFTWARE) MODEL DEVELOPMENT

Complete-Smart software is developed for the horizontal and extended reach well completion operation for optimum well delivery. It contains several modules which include: Circulation modeling, Pump output modeling, Packer setting and spacing out etc. *Complete-Smart* software was developed from the platform of Microsoft Visual Basic.Net. It uses the basis of Visual Basic (VB) Programming Language. It has the advantage of easy to use and very simple analysis. It can be applied by engineers in the oil and gas industry and those in other industry outside oil and gas. It can easily be upgraded and updated and has the flexibility of being re-designed for special operations should a customized operation is required. It's simple analytical method is intriguing and you don't have to click too many buttons before getting the required result. The flow chart for the model development of *Complete-Smart* software, the lower and upper completion workflow are shown in the **Appendix** A, B and C

VI . MODELING HYDRO TRIP FUNCTIONALITY

The chasing pressure, Shearing efficiency and the travelling velocity including all forces acting on the hydro tri sub ball could be modelled. These includes: Up trust, gravity due to its own weight, buoyancy and the shearing force applied.

The advantage of this model is that it is used as a Tempory tubing plug for setting hydraulically actuated packers in single and dual well completions. It can be run at any location in the tubing string, has the features of full tubing ID ater shearing, one body joint with antitorque locking screws, adjustable shaer value reliable shear mechanism, and allows circulation prior to dropping ball.

VII. CASE STUDY

The Uniport North 55ST is located in the eastern part of the Niger Delta. The field was discovered in October 1963 by exploratory well Uniport North 01 to date. The field has been developed by 55 wells with a total of 98 drainage points oil production from the field commenced in October 1955. A total of thirty seven hydrocarbon bearing reservoir has been penetrated in the field which lies within the paralic sequence between 6,000 fss and 10,000 fss. The field contains 59 oil bearing and 11 gas bearing reservoir. The main objective of the Uniport north 55ST well completion phase was to drill the horizontal section and install a sand control system that will be stand alone and horizontal oil producer on the C9000A, sand with 3-1/2 HCS producing string. Install 3-1/2 TRSCSSSV and PDHS for safety and well surveillance respectively as well as gas lift mandrel for future artificial lifting.

Summary of Rig Specification

Table1.: Rig Specification

Rig Contractor	KCA Deutag
Rig Name	T-76
Rig Type	National 1320
Clear Height of Mast	142ft
Max. Static Hook Load	454 tons
Draw works	

Top Drive System	TDS 95
RKB / GL	9.06m

VIII. DISCUSSION OF CASE STUDY

Using *the developed model* the pore pressure and fracture gradient profile was used to determine the casing setting depth, burst and collapse criteria design and in the final selection of the available casing.

The simulation was based on the principle of Monte Carlo probabilistic method. Figure 2 shows the probability frequency distribution of every reservoir pressure class within the reservoir system. The probability that any of the class center lies between the minimum and maximum value can then be computer. For instance, the probability that the reservoir pressure is less than equal to 5500Psi is 91.98%. This provides a very strong confidence level.

, The casing pressure was recorded at 100Psi while the spike pressure after the ball had shear was recorded at the surface as 3961Psi.

The torque, drag and over pull for the operation is presented in (**Figure 5**). While the pump pressure was calculated as 2950psi as seen in **(Figure 3)**

The tubular displacement volume was 0.00652 bbl while the total weight of string and other down hole equipments along the vertical section of the hole was calculated as 19.5Ib **(Figure 6).** This analysis is vital in order model rotary speed, torque, drag and over pull during drilling and completion operations.

The trip time for the completion operation was calculated to last for a period of 8.31522hr.The casing string displacement while lowering into the hole was 0.00652(bbl/ft) and the capacity of the casing string was calculated as 0.00415(bbl/ft) as shown in (**Figure 7)**

The pressure surge and swab were determined as 11.8571ppg and 9.1429ppg respectively. These pressures are relatively small and manageable and may be easily controlled to avert any possible danger of kick (**Figure 8) .**

IX. PACKER SETTING DEPTH, SPACING OUT AND SEALS STABBING

The packer setting depth was captured in the model. If the packer is set too low it may become stuck in the cement. Generally the packer is set 30 - 50 ft above the perforations. Sometimes a tail pipe is used below the packer to ensure that only cement is squeezed into the perforations, and there is less chance of setting. However, Bridge plugs are often set in the wellbore, to isolate zones which are not to be treated . for his case study , the pup joint to be POH was calculated as 54.8ft (figure. 9) which is enough to prevent leakage of pressures.

X. OPTIMIZATION MODEL

In order to optimize this base result an optimized model was developed assuming two models. These models are:

- Moving Average Model

- Linear Model

The resultant equation is thus;:

$\mathrm{EMA} = 0.25\mathrm{PV} + 0.75\mathrm{EMA}_{(i-1)}$ (See **Figure 11**)

Where;

EMA = Expected Moving Average ($);

PV = Present Value of money

i-1 = immediate terms before the present vale

The average error of the moving average model is Er = 0.1454.

The resultant equation is thus,

$EC9(i) = 43.4624 + [99.0437]ST$ (See **Figure 12 –** *Complete Smart model)*

Where;

EC = Expected cost ($);

ST = Present Value of money

i-1 = immediate terms before the present value

The average error of the moving average model is Er = 0.0569.

From the above developed model, critical analysis of obtained results using both moving and linear models shows that slick line completion in that areas will take about 374 hrs (15.58days) while using hydro trip sub completion technique (slick less line operation) will only take 212 hrs (8.83days).

Also, the cost of slick line operation for the 374hrs. (Was $45,800 while it was $16,800 for hydro trip operation. The overall advantage of hydro trip operation was to optimize completion processes saving 162hrs. (6.75 days) and $ 29000.

XI. Conclusion

Completion optimization is a highly technical task that requires robust energy, skill and equipment in order to achieve desired objectives. If careful selection of equipment is carried out, completion optimization in ERW will be highly efficient and effective. The performance of the Opukushi North 55ST Oil wells, was optimized by carefully incorporating the application of the reservoir drilling fluid with the completion installation fluids and processed. This method reduced cost, NPT and completion was optimized

XII. Recommendations

- Reservoir drilling fluids can and should be formulated and maintained to minimize the potential for impairment of both the formation and the installed completions, especially for sand control completions.
- Specific limit should be established for the accumulation of total insoluble solids and clays with RDF system while drilling.
- RDF additive selection should consider both drilling functionality and the facilitation of filter cake removal by chemical treatment
- Performance meters established for operational processes involve in the drilling and completion of a reservoir interval

should be directed toward final well performance objective.

- Ensure proper equipment selection and QA/QC as priority.
- All sub assembly to be for completion should be pressure tested and charted.

- Experience personnel should be sent on refresher courses on well completions in order to be fully updated. If all these key factors are considered, the problem of extended reach and highly deviated well completion will be moderately reduced if not totally eradicated

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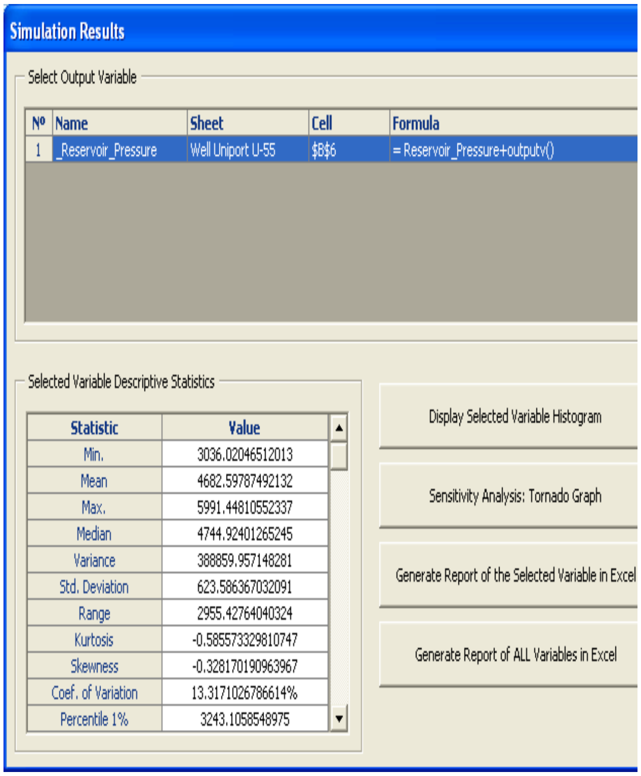


Fig.1: Statistical Parameters of simulated reservoir data

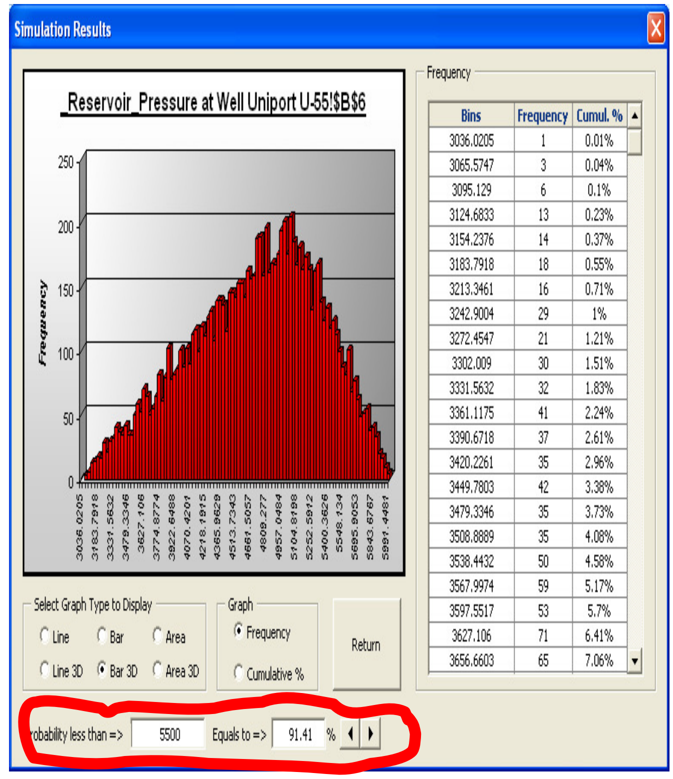


Fig. 2b: Formation Pore Pressure and Fracture Pressure data of Uniport U

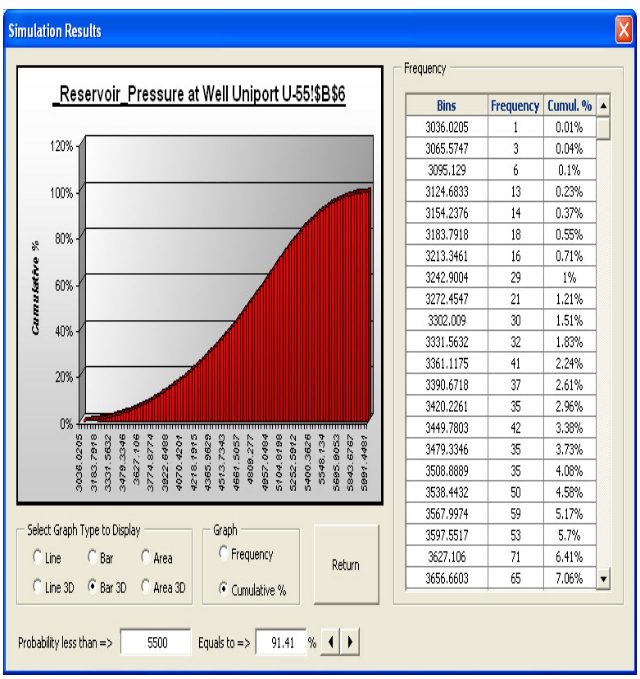


Fig.. 2a. Frequency distribution of the output variable (Reservoir Pressure)

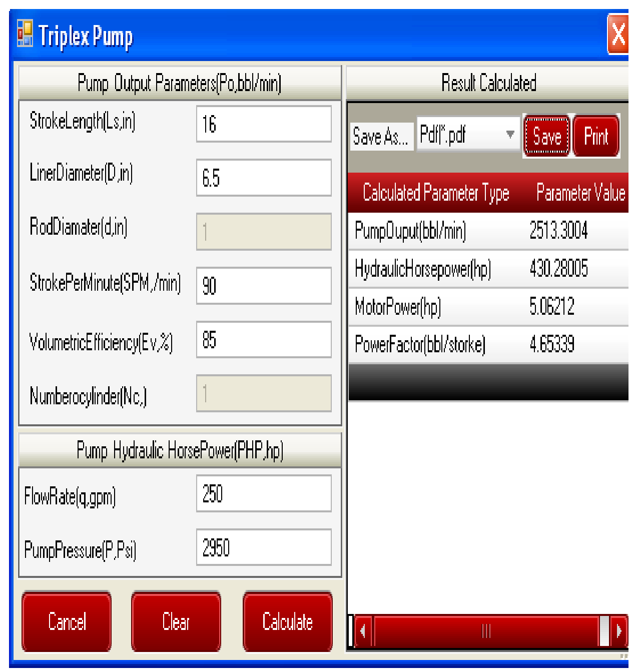


Fig. 3: Pump model and calculation result

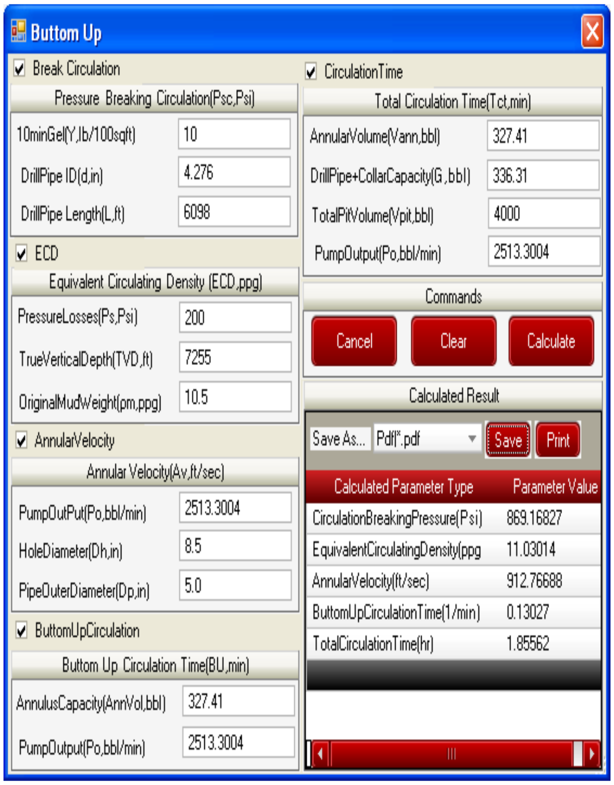


Fig. 4: Pump Circulation model

Fig. 6 for trip time operations

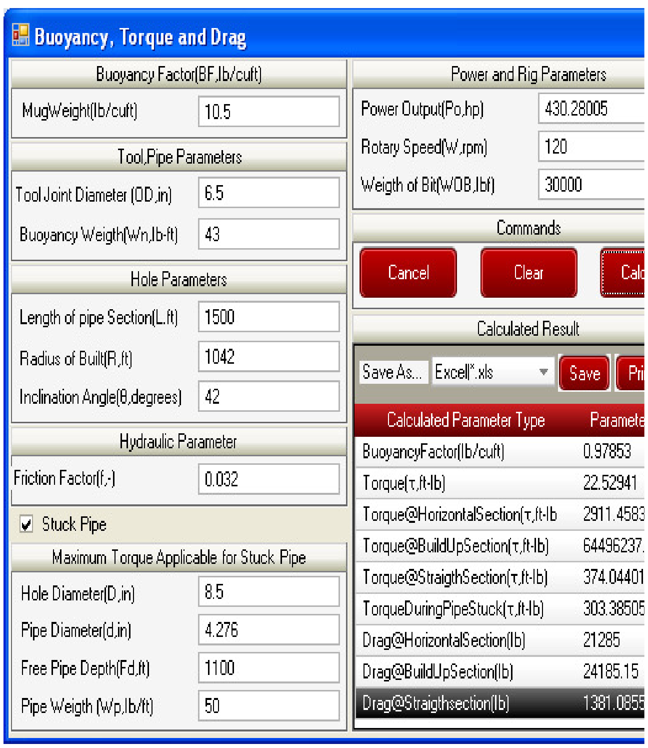


Fig. 5: Complete-Smart showing input interface for Torque, Drag and over pull model

Fig. 7. For trip time and trip rate calculation

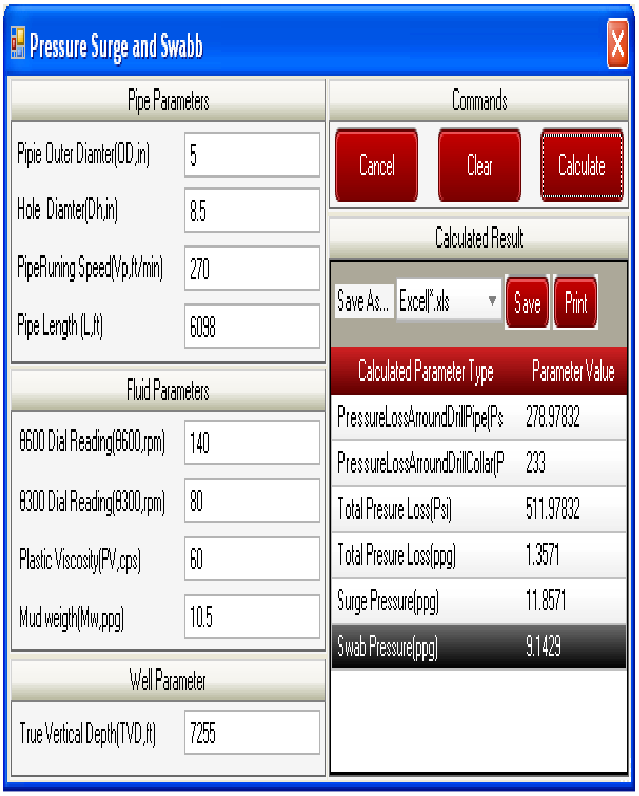


Fig. 8: Complete-Smart showing Input interface for Pressure Surge and Swab Pressure

Figure 9 . Packer setting and spacing

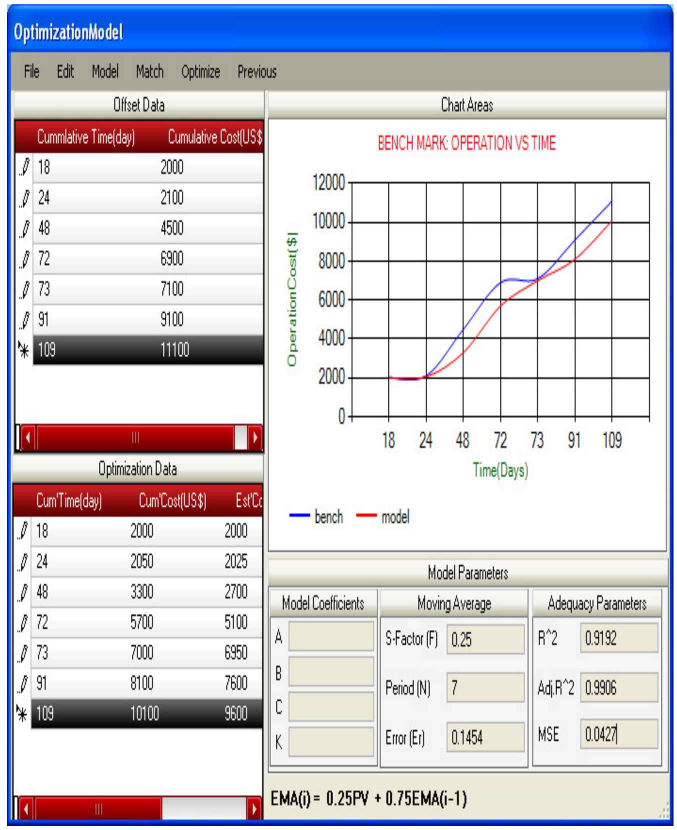


Fig .10 Optimization model

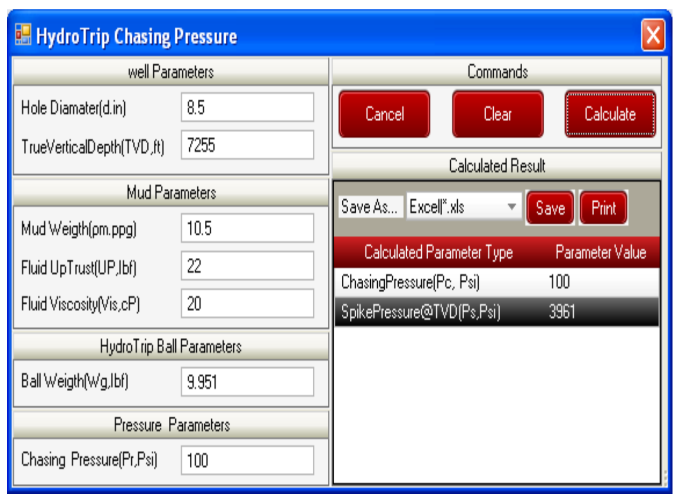


Figure 11: Moving Average model completion Optimization snipped shot

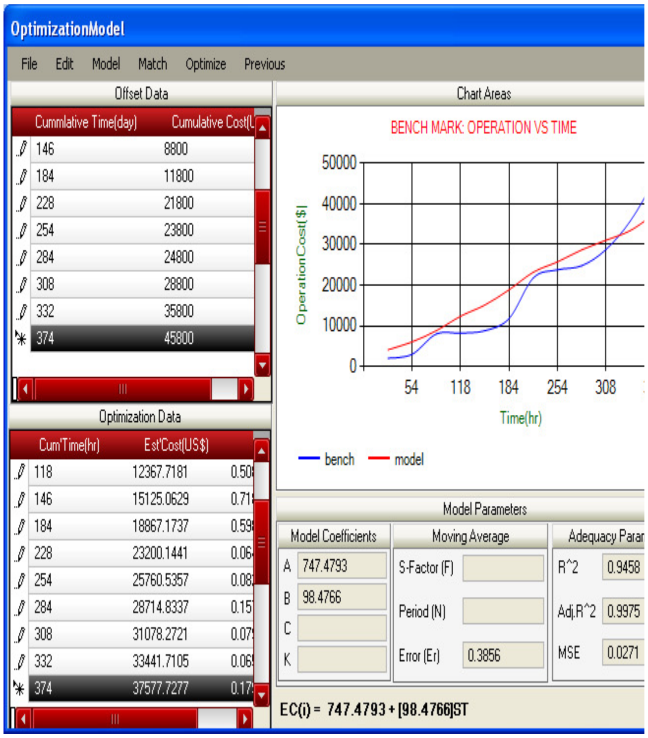


Fig. 12:Linear model completion Optimization snipped shot

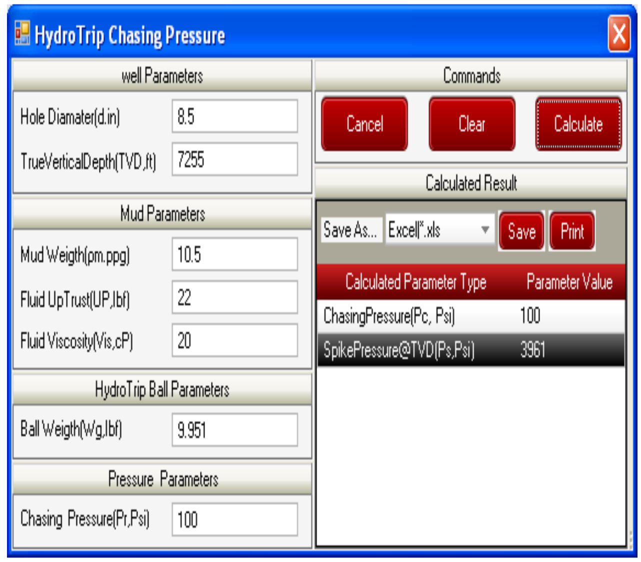


Fig. 14. hydro trip casing pressure determination

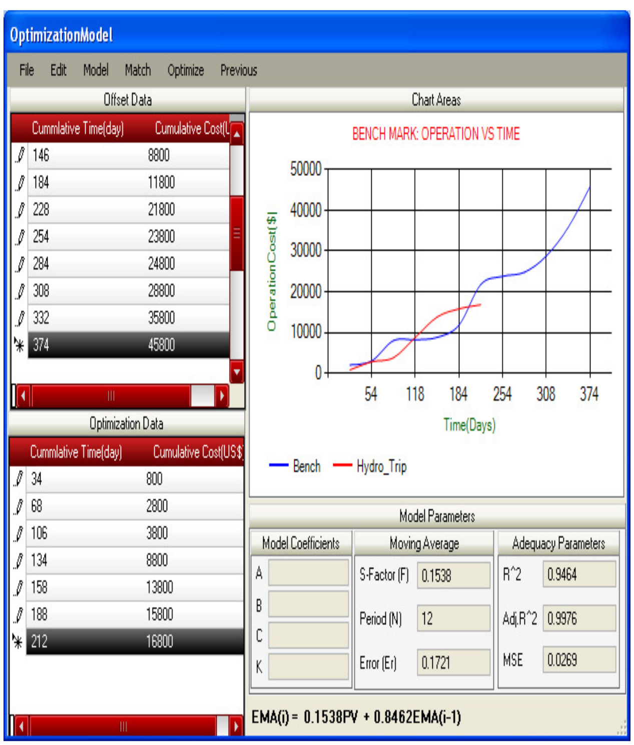
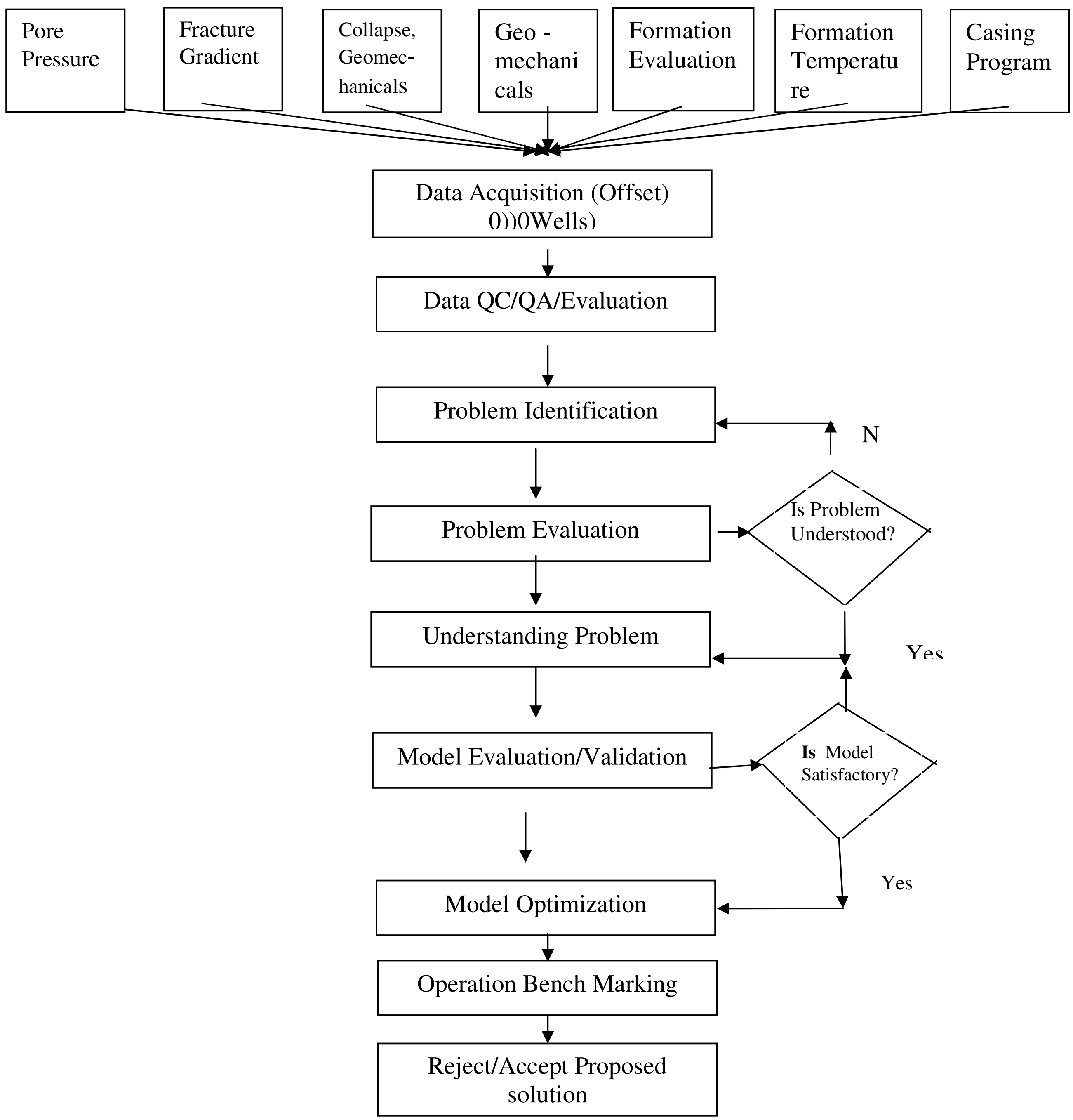
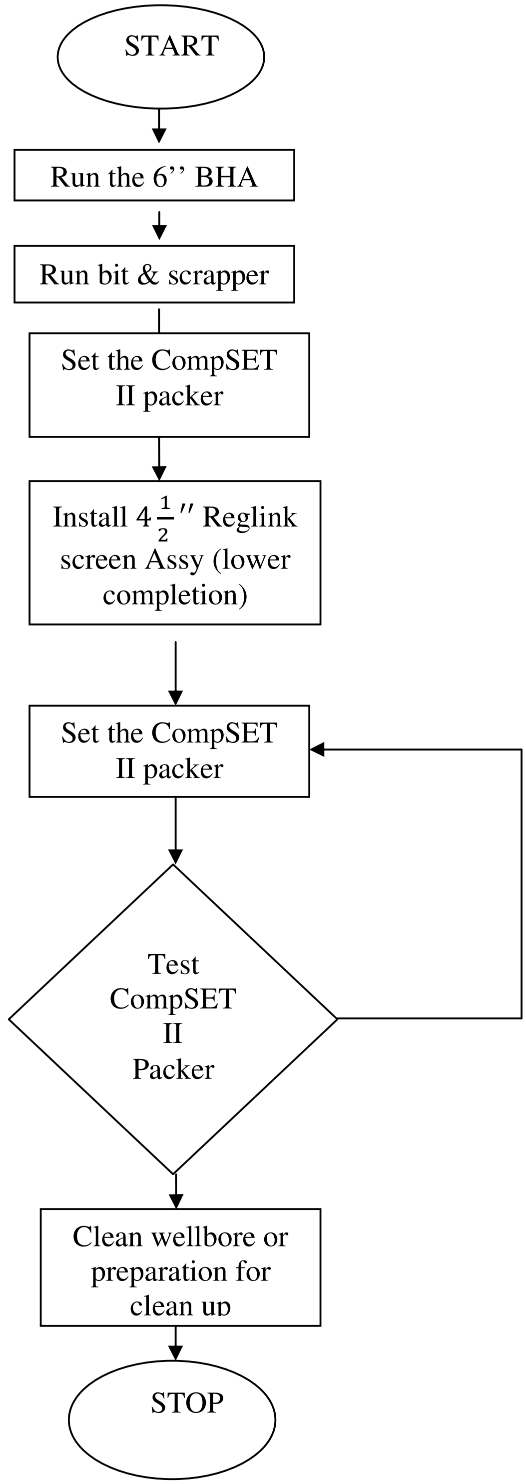


Figure 13: Optimize hydro trip operation model

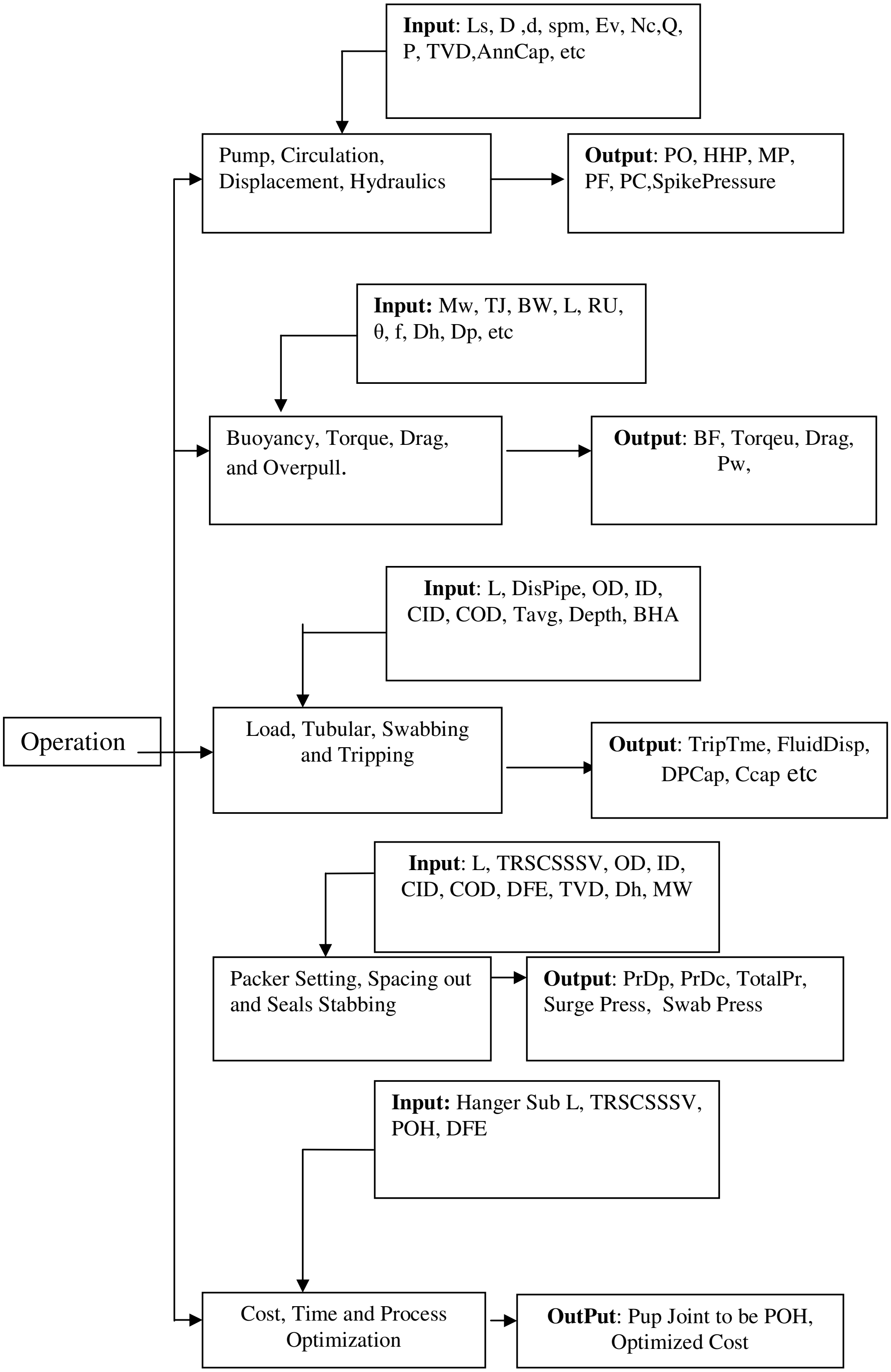
APPENDIX A : PROCESS FLOW DIAGRAM OF OPERATION METHODOLOGY



APPENDIX B- PROCESS FLOW DIAGRAM FOR LOWER COMPLETION



APPENDIX C: PROCESS FLOW DIAGRAM OF COMPLETE SMART SOFTWARE



APPENDIX D - PROCESS FLOW DIAGRAM FOR UPPER COMPLETION SECTION