PNGE 480
Petroleum Engineering Design

SEMESTER-LONG PROJECT

Your group is a reservoir engineering consulting company. Following is what you need to do as a group in order to complete the requirements of this course. In short, you need to submit a proposal to an operator, perform a reservoir engineering study on one of their assets and provide them with a final report that includes tangible results and actionable items. Your grade at the end of the semester will depend on how well you perform the analysis and how effective you are in convincing the operator to implement your recommendations. You will be graded by WVU-PNGE faculty as well as the operating company representative.

Step One: Proposal Submission

During the first step of the project you have to identify an operator to perform a reservoir study for one of their assets. You may want to select a local operator since it will increase the possibility of their cooperation (that you surely need) throughout the project. Using your contacts (summer jobs and internships) would be a great idea and usually your best bet for success.

Identify the asset that would be a good candidate for your reservoir study (this is done together with the operator). Keep in mind that you need about 75 to 100 wells present in the asset that you are studying. As the number of wells in the asset increases, so does the accuracy of your analysis. It would help if you do a bit of homework prior to approaching the operator. You must convince the operator that you have a unique approach that would add value to their operation. Write a proposal about the project (it will be explained in detail in the following sections and an example proposal is provided to you), present it to the operator, get their approval.

You will be offering your services to perform a unique reservoir engineering study for the operator. Your study would be based on the lectures in this course as well as what you have learned during your past several years as a PNGE student. Material covered in PNGE 441 (Oil & Gas Property Evaluation) will be the main foundation for your unique approach. Uniqueness of your service has to do with the fact that you perform all your study and provide tangible results while using production rate data as the only required data. Keep in mind that although production rate data (and of course well locations) are the minimum requirement, any data and information (for as many wells as are available) that the operator can make available to you such as core data, logs, well tests, results of previous studies such as seismic and simulation and modeling can be incorporated in your analysis and improve the probability of

success. You have to be able to effectively communicate this fact to the operator in order to entice them into providing you with as much information and cooperation as they possibly can. But the most attractive aspect of your unique approach is that all these other information that were mentioned above are not requirements for you to perform your analysis rather they are icing on the cake, to increase your probability of success. This is due to the fact that the technique that you are employing has been specifically developed for mature fields that usually do not have much data above and beyond the production rate data.

Furthermore, you need to emphasize that the outcome of your study is:

a. Estimation of Remaining Reserve
b. Identification of best location for infill drilling
c. Identification of under-performing wells for remediation purposes.
d. Identification of current recovery factor along with recommendations on how to improve it.

In your verbal and written communications with the operator you need to emphasize what you need from them. In other words, what does this study cost the operator. This is the most attractive part of your approach since you are not asking for any monetary compensation. But you have to secure commitments from the operator to see the entire project through. Absolute minimum requirements from the operator include:

a. Provide data to the team.
b. Provide any geological expertise that they have available in the company in order to increase probability of success.
c. Meet with you during the project to review your progress and provide feedback.
d. Have a representative present at WVU Morgantown Campus during the final presentation of the project (Thursday April 10, 2008 – Noon till 3:30 PM).

Please notify the operator that you will be providing them with a monthly progress report. Please file these reports with us as they will count toward your final grade.

Step Two: Perform the Study & Complete the Project

This step includes the main body of the project. During this step you complete the project requirements as a team. Your cooperation as a team is vital to the success of the project. You may use the project that you completed in PNGE 441 as a blue print for this project. This project is much more comprehensive and includes many more wells and several more components. The foundation of the approach that will be used in this study may be found in the following publications. Please consult more SPE publications that you find to be relevant to the topic of your project. Make sure that you adequately reference all the material that you use during the project in your oral presentation and written technical report.

- "A New Method for Production Data Analysis to Identify New Opportunities in Mature Fields: Methodology and Application." Mohaghegh, S. D., Gaskari, R., Jalali, J. *SPE 98010, Proceedings, 2005 SPE Eastern Regional Conference and Exhibition.* September 14 – 16 2005, Morgantown, West Virginia.
- "Identifying Infill Locations and Underperformer Wells in Mature Fields using Monthly Production Rate Data, Carthage Field, Cotton Valley Formation, Texas." Jalal Jalali, Shahab D. Mohaghegh, Razi Gaskari, West Virginia University, *SPE 104550, Proceedings, 2006 SPE Eastern Regional Conference & Exhibition.* 11-13 October 2006, Canton, Ohio.

- "An Integrated Technique for Production Data Analysis with Application to Mature Fields." Gaskari, R., Mohaghegh, S. D., Jalali, J. SPE Production & Operations Journal. November 2007. Volume 22, Number 4. pp 404-416.

Your study must include a geologic review of the area being studied. This can be accomplished on your own or in cooperation with the operator (recommended), your report and presentation must have a geology component.

Some of the items that you are to cover during the project will be covered during the lectures in class. It is very important that you stick to the timeline and the schedule that is presented to you (attached to this document). Failure to submit the required reports (verbal and/or written as indicated in the schedule) will result in deduction of points from your final grade. Your project includes the following items. Keep in mind that analysis that are identified for individual wells must be performed for all the wells that are included in the study (at least 75 wells and as many as 200 wells) while field-wide analysis include a single analysis for the entire field.

A. ***Decline Curve Analysis.***
   Perform Decline Curve Analysis for all the wells.

B. ***Type Curve Matching Analysis.***
   Perform Type Curve Matching Analysis for all the wells in the field. You may use the results of Decline Curve Analysis in order to decrease the subjectivity of the Type Curve Matching. Furthermore, make sure that the Estimated Ultimate Recovery calculated as a result of Type Curve Matching is comparable to that of Decline Curve Analysis.

C. ***History Matching.***

Perform production rate History Matching using a radial numerical simulator for all the wells involved in the study. Again, make sure that the Estimated Ultimate Recovery calculated from your History Match is consistent with those calculated during Type Curve Matching and Decline Curve Analysis.

NOTE: Please note that it may be required for you to iterate between History Matching, Type Curve Matching and Decline Curve Analysis in order to converge to a reasonable set of reservoir characteristics.

D. ***Relative Reservoir Quality Index.***

Map the Relative Reservoir Quality Index for the field using the following Production Indicators (PI). You have to make sure that your maps – delineation of areas – make sense as far as the average value of the PI is concerned for each region):

- Production Indicators calculated from the production data.
  - First three months of production
  - First year of production
  - First three years of production
- Production indicators calculated from Decline Curve Analysis
  - Initial Production Rate
  - Initial Decline Rate
  - Hyperbolic Exponent
- Production indicators calculated from Type Curve Matching Analysis
  - Permeability
  - Fracture Half Length
  - Drainage Area
- Production indicators calculated from History Matching
  - Estimated Ultimate Recovery

E. ***Remaining Reserves.***

Qualitative maps of Remaining Reserves as a function of time and different development strategies.

F. ***Infill Drilling Locations.***

By cross referencing the results from Remaining Reserves and Permeability as well as other maps that you have generated, identify, list and rank the best locations for infill drilling in this field.

G. ***Underperforming Wells.***

Based on your analysis provide a list of the underperforming wells and rank them in terms of their potential for improvement potentials.

H. ***Volumetric Reserve Calculation.***

Delineate the estimated drainage volume for each well using Voronoi Graph Theory in conjunction with the theory of image wells. Adjust the boundaries of the estimated drainage area to account for differences in volume of the hydrocarbon that has been produced. Calculate the Estimated Volumetric Reserve for each well based on the estimated drainage area. Make sure that you clearly state the assumptions involved in your calculations.

I. ***Recovery Factor.***

Cross analyze Decline Curve Analysis with Estimated Volumetric Reserves in order to calculate field-wide recovery factor.

J. ***Field Development Strategies.***

Optimize field recovery factor via infill drilling recommendations.

Step Three: Deliverables & Completion of the Project

To complete the project you must perform and submit the following items:

a. Decline Curve Analysis of all the wells involved in the study.
b. Type Curve Matching Analysis of all the wells involved in the study.
c. Production rate History Matching (using a numerical simulator) of all the wells involved in the study.
d. Map of Relative Reservoir Quality Index for the field.
e. Qualitative maps of Remaining Reserves as a function of time and different development strategies.
f. List of locations (with Ranking) for infill locations.
g. List of underperforming wells.
h. Delineate the estimated drainage volume for each well using Voronoi Graph Theory in conjunction with the theory of image wells and estimate volumetric reserves.
i. Cross analyze Decline curve analysis with estimated volumetric reserves in order to calculate field-wide recovery factor.
j. Optimize field recovery factor via infill drilling recommendations.

Results of you analyses are to be presented to PNGE faculty and student body as well as to the representatives of the operating companies through:

1. A comprehensive Presentation of all your findings.
2. A detailed written technical report on your findings.

Format of the Final Report: Your final report must be professionally bounded with hard cover (the same format as the Masters and Ph.D. theses). Only one such copy is required. This copy will remain in the department as a record of your work. Attached is a cover page that should be used for the design of the hard cover of your final technical report.

A copy of this report should be presented to the operator at the conclusion of your project at the same time that you submit your final report to me for your final grade. The copy presented to the operator does not ***HAVE TO*** be in the same physical format as the one presented to the department, although it might be a good idea for them to look the same. Make sure that you include a disclaimer in your final report that is submitted to the operator.

Writing a Technical Proposal

Your proposal to the operator must be concise, to the point and effective. It must demonstrate that you understand the problem, have a solution and are capable of delivering the required results. It should follow an oral presentation or discussion that has built the foundation for the project. During your oral discussion you have to present the same items that will appear in your written proposal but with a personal touch and a professional attitude that exuberate confidence and competence.

Attached to this document you find an example of a technical proposal as a potential guide to prepare your proposal to the operator. Add your own touch to it.