CHAPTER X

CONCLUSION

This work is intended to investigate the possibility of using surface information to control production of the solution gas drive reservoir under the natural depletion process in order to gain optimum ultimate oil recovery. A commercial black oil numerical reservoir simulator was used for generating data for the study. Empirical correlations which are accepted in the reservoir engineering field were used for generating properties of fluids and rock required by the simulator. A number of simulation runs were conducted. Certain reservoir and fluids' properties were changed according to the purpose of the investigation. The simulation was based on the radial numerical reservoir model.

It is found that ultimate oil recovery from the natural depletion process of a solution gas drive reservoir is independent on maximum allowable oil production or plateau rate. This is true for any set of fluid properties. However, different fluid set gives different ultimate oil recovery. The reservoir can be produced under a variety of maximum allowable oil production rates and its ultimate oil recoveries become identical at the abandonment of the natural depletion process. However, different maximum allowable oil production rates will result in different time of reaching the abandonment when the maximum allowable oil production rates are lower than a certain value. The average reservoir pressure at abandonment of the cases with high maximum allowable oil rates are approximately equal, provided that the maximum allowable oil rates are higher than a certain value.

Extensive investigation was made for heterogeneous reservoirs represented by a numerical reservoir model having normal distribution porosity and log normal distribution permeability. The results revealed that heterogeneity have insignificant effect on the relationship between maximum allowable oil rate and ultimate oil recovery. However, it affects ultimate oil recovery and times of obtaining equal oil recovery.

For the conclusions above, the investigations were made at sand face in order to exclude the effect of changes occurring in the tubing, hence the actual effects of the reservoir system can be investigated. In order to apply the findings about the influences of the reservoir system to the actual production operations, a tubing lift table was included in the model. This tubing lift table was generated from another application included in the same package of the black oil simulator. It was also found from this latter investigation that the effect of maximum allowable oil production on ultimate recovery was negligible. In addition, the limitation of minimum flowing tubing head pressure did not effect ultimate oil recovery from natural depletion process. It had affected on recovery at various time points though. At any time point, oil recovery from the cases which allow the well to produce at higher maximum allowable oil rate will be higher, provided that the maximum allowable oil rates used are lower than a certain value. Though, ultimate oil recovery at the abandonment of natural depletion process of each case is approximately equal, the case with lower maximum allowable oil rate would have to produce for longer time.

For a reservoir having a well producing under a certain limitation, for instance, minimum economic rate or minimum flowing tubing head pressure, a maximum allowable oil production rate equal to or greater than a certain value results in similar oil recovery fraction curves. In addition, certain conventional plots of other information, for instance, GOR or part of oil production rate plot, are also similar. This leaded to the consideration of a threshold rate which resulted in identical production behavior. Hence, an identifier which might be used for adjusting production rate in order to gain better oil recovery as a function of time was searched.

Additional plots of surface information were made for investigation. Additional plots included plots of derivative of oil production rate, GOR, and flowing tubing head pressure with respect to producing time versus producing time. Plots of both first and second order derivatives were made for investigations.

Among these derivative plots, a plot of the first order derivative of flowing tubing head pressure showed a unique trend. Plot of first order derivative of GOR and oil production rate were not useful for identification. The shape of derivative of GOR obtained from each case had almost the same shape but it occurred at different time for each case. Plots of second derivative of these information, e.g. oil rate and GOR, did not have unique shape as well. Therefore, these plots were not useful for identification either.

Plot of the first order derivative of flowing tubing head pressure was used as an identifier for improving oil recovery. The shape of this derivative is unique. At the early stage of production, the curve of derivative of flowing tubing head pressure was negative. This curve tended to approach zero as the well was producing. The cases with high maximum allowable oil rates had the curves which approached zero within short time period. In contrast, the derivative of the cases with lower maximum allowable oil rates approached zero within much longer producing time. The unique shape of the derivative of flowing tubing head pressure for the threshold maximum allowable oil or plateau rate has been identified.

The second order derivative of flowing tubing head pressure did not show any unique characteristics. Therefore, it was considered that the second order derivative of flowing tubing head pressure plotted against producing time could not be used for identification purpose.

The results from this study can be used to specify optimum plateau rate after having some production data. All the conclusions for this study is applicable to the solution gas drive reservoir only.