Graduate Studies: Are They Advantageous To The Practicing Petroleum Engineer?

D. R. Skinner, P.E.

ABSTRACT

The return to a university for graduate studies after an engineer has begun practice in the petroleum industry is discussed. Some factors motivating advanced studies are given. Several general programs are outlined and described. Justification of the time and effort required for study leading to a master's degree for both engineer and employer is considered. This presentation concludes that graduate studies are not desirable for many, perhaps even most practicing petroleum engineers; but some engineers gain professionally and personally from such studies.

INTRODUCTION

As the time for graduation nears, most engineers have completing studies and securing the best position possible after graduation foremost in mind. For many, the thought of continued study leading to the degree of Master of Science in Engineering is not only foreign but is almost repugnant. Some of these graduates, from virtually all engineering disciplines, will have been recruited and hired by petroleum companies. The degree of Bachelor of Science that these graduates earn will carry many of them through their entire careers, but some will find that they need additional academic training to attain their career objectives. These latter graduates may wish to consider additional study leading to the degree of Master of Science in Engineering.

NEED FOR ADDITIONAL ACADEMIC TRAINING

Most engineers find that their academic background in a bachelor program augmented by formal and informal industrial training and experience entirely satisfies their career objectives. Many of these engineers are or plan to become engineering supervisors and/or managers and feel that a more general and less theoretical background is an asset to their careers. Others feel that a general and traditional career in engineering satisfies their needs. These individuals generally apply and perfect but seldom develop innovations in technology. Finally, there are those who specialize in areas that are almost wholly emperical and feel that theoretical work might be a liability rather than an asset th their careers.

There are a few engineers, however, who perceive a weakness in their backgrounds and feel that this weakness may prevent them from achieving their career goals. These individuals may feel that additional academic work in their chosen specialty area would be of immediate or future benefit to them. Others might feel that they could do truly innovative engineering work if they improved their academic backgrounds. Still other might wish to seek academic work in an area completely different from their original engineering studies. Finally, there are those who feel the additional work in their own discipline

will allow them to improve their knowledge of advanced concepts and latest developments in the "state of the art".

This latter group ot engineers would probably benefit from undertaking post-baccalaureate studies leading to a master's degree in engineering. Many of these engineers prefer to conduct study while they are employed in the petroleum industry and prefer enrolling at a local university. Others may prefer to take a leave of absence so that they may attend a local or remote institution on a full-time basis. In either case, the individual must carefully consider the study he wishes to pursue, the availability of this course of study, and the justification he expects from such a program.

ENGINEERING GRADUATE STUDIES

When a practicing engineer makes the decision to undertake additional studies the individual must be prepared both mentally and physically for such work. The engineer must be prepared for working with younger students and for entering the somewhat competitive academic environment. The academic work will be more demanding than undergraduate work was, and performance standards must be higher than they were for undergraduate work. An engineer must understand and appreciate these facts prior to entering graduate study.

Program Selection

Some engineers choose to take a leave of absence to pursue graduate studies on a full-time basis, and the individual may choose to attend any institution at which admission may be gained. Others wish to continue working on a full-time basis and study part time. In such cases, the choice of institutions is limited to those which may be reached easily.

The choice of a course of study is the most critical for a practicing engineer. Depending on the individual's reason for advanced study, he may choose courses which are not a part of a standard degree plan at a particular institution. It may well be that the institution chosen by the individual may offer a degree plan which covers only those areas of interest; but, if the choice of universities or degree programs is limited, the engineer probably must take more courses than intended. Most engineering departments will allow an individual to take as many courses as he wishes, but they will only accept specific courses for a particular degree plan. Another alternative available at many institutions is a multi-disciplinary degree plan in which the individual may study several areas of engineering, science, mathematics, and other fields but still earn a single degree.

The final alternative, simply taking courses without ever intending to earn a master's degree is also available to most individuals. There are several drawbacks to this approach; however, and it is the author's opinion that this is a less than satisfactory approach. First, many companies monetarily support academic work of their employees provided that satisfactory progress can be shown; and an institution cannot certify such progress without a standard such as a degree plan for comparison. Academic work without a degree plan is generally disjointed and may be inefficient in producing the knowledge desired by the individual. Many master's degree plans culminate with a thesis or a master's project - work that requires independent and

creative work; and study without a degree in mind deprives the engineer of the opportunity of performing this work and using it to demonstrate his achievement. Finally, graduate studies which do not produce an actual degree leave the engineer with nothing to show for his work except his own personal satisfaction.

General Program Requirements

When an engineer enters graduate level study, he must be academically prepared for the advanced work. This preparation usually takes the form of attending undergraduate courses without master's degree credit to learn basic material unfamiliar to the individual or to improve his knowledge in areas of weakness. If the engineer is entering a discipline different from that of his original degree, he may have to take 30 to 40 semester hours of undergraduate courses (i.e., the equivalent of a second bachelor's degree) before beginning master's level work in that discipline.

One of the first areas that deserves additional study for virtually any engineer is mathematics. Upon graduation from most bachelor's programs, an engineer had studied the rudiments of calculus, ordinary differential equations, and applied mathematics; and even though these areas are adequate for much engineering work, they seldom give an engineer a substantial background for some of the advanced work in field theory, optimization, and modeling. A practicing engineer should consider studies in statistics, advanced ordinary, partial, and nonlinear differential equations, vector calculus, and numeric analysis for most advanced studies even if the degree program chosen does not require all these areas of study.

It is a fact of life that computer systems are an integral part of all technological systems. No engineer, regardless of discipline can hope to truly excel in advanced studies without a thorough working knowledge not only of programming but also of computer systems in general. Anyone seeking advanced knowledge must be prepared to study computer science to a certain extent. One or two advanced programming courses as well as studies of numeric analysis, linear programming, and data structures should be considered imperative by any practicing engineer performing advanced studies.

Advanced study of the sciences is usually the principal reason for graduate studies. This study may take the form of study of strictly scientific areas such as chemistry and physics or it may take the form of enrollment in disciplinary courses which cover narrow specialty fields within the broader area of basic science. The choice of studies, of course, depends on the area within which advanced knowledge is desired and on the area of the petroleum industry with which the individual is concerned. Some of the areas of study may be subdivided by industrial specialty as follows:

Reservoir	Production
Advanced Reservoir Study	Physical Chemistry
Field and Wave Theory	Thermodynamics
Partial Diff. Eq.	Fluid Mechanics
Numeric Analysis	Electrical/Electronic Systems
Optimization	Optimization
Modeling	Corrosion

Enhanced Recovery	Instrumentation/Control
Advanced Reservoir Study	Electrical/Electronic Systems
Field and Wave Theory	Advanced Control Theory
Fluid Mechanics	Numeric Analysis and Control
Physical Chemistry	Fluid Mechanics
Organic Chemistry	Optimization
Optimization	Basic Reservoir Theory
Modeling	Basic Production Technology

Drilling	Offshore Technology
Advanced Mechanics	Advanced Mechanics
Vibration Theory	Vibration Theory
Advanced Metallurgy	Advanced Metallurgy
Rock Properties	Wave Mechanics
Fluid Mechanics	Fluid Mechanics
Electrical Machinery	Electrical Machinery
	Corrosion

EFFECTS OF ADVANCED ACADEMIC STUDY

The final test of advanced academic study is determining its effect on a practicing engineer. Several key questions must be asked and answered. What can an engineer do after such study that he could not have done before? What monetary, intellectual, or other benefits can an engineer expect to gain? What can an engineer's employer expect to gain by his earning a master's degree? Does the engineer have more monetary value to his employer; and if so, how much more?

Mathematics and Modeling Skills

One of the first benefits to be expected from graduate studies is an increase in an engineer's knowledge and application of mathematics. In the largely emperical field of petroleum engineering, this may not seem important until the concept of modeling is considered.

Mathematical modeling is increasingly important in all phases of petroleum exploration, recovery, and production. The most familiar technique is that of reservoir modeling, but other processes such as artificial lift systems, fluid flow in gathering systems, separation and treating systems, and recovery can be analytically modeled with sufficient mathematical background.

The principal benefit to be gained from advanced studies is not an engineer's ability to develop or even operate a particular modeling system. The benefit lies in the engineer's ability to grasp or develop new or untried techniques. This somewhat nebulous benefit is the result of the engineer's increased mathematical ability.

Conceptual Skills

Another important benefit to be expected from graduate studies is an improvement in intellectual perception of various aspects of the petroleum industry. This improvement comes as a result of the method by which a graduate student is expected to perform in most institutions' graduate courses. In most graduate studies, the

mechanistic approach of some undergraduate programs is abandoned in favor of an intellectually inquisitive approach.

An engineer's advanced study of physical and disciplinary sciences should prepare him to approach most facets of the petroleum industry with the question "why" rather than "how". For example, a graduate engineer might prefer a mathematical approach using thermodynamics, physical chemistry, and fluid mechanics to describe an oil/water treating system rather than the emperical charts and tables so commonly used. It is this inquisitive nature fostered by graduate studies that represents the greatest potential benefit to both the engineer and his employer.

With the advent of "enhanced recovery", a number of the commonly accepted emperical techniques for determining recovery and production system behavior have had to be reconsidered. Modeling, or mathematically describing and analyzing a system, has become increasingly important in conventional production systems and almost critical in those systems employing some of the enhanced recovery technologies. Fluid behavior, reservoir mechanics, phase behavior, and production system operation in enhanced recovery processes are critically important and are handled analytically because so little emperical information is available.

Even such supposedly mundane topics as instrumentation and control and mechanical and electrical system efficiency are receiving increasingly close analytical attention because of the large costs of petroleum production and fluctuations in oil and gas prices. These analytical, and sometimes theoretical, areas of the petroleum industry are those for which the academically advanced engineer prepares himself.

Individual Incentive

The most important benefit to be gained from graduate study is the ability to conceive, develop, and implement different and sometimes innovative techniques for approaching various aspects of the petroleum industry. Prior to undertaking advanced studies, an engineer already had to possess an inquisitive mind and have enough individual incentive to be able to perform independent work. In virtually every course, the engineer is encouraged to work independently of the faculty and advisors of an institution. This concept culminates in a master's thesis and, to a lesser extent, in a master's project, in which an individual is required to develop a concept and actually contribute to the body of knowledge of a subject.

It is this enhancement of individual incentive that offers great potential to an engineer and his employer. An engineer expects to improve his intellectual and technical ability to perform truly innovative work by advanced study. In most cases, this objective is attained.

JUSTIFICATION OF GRADUATE STUDIES

In the final analysis, a practicing engineer must be able to justify the time and effort required for attainment of a master's degree to himself, and perhaps to his employer. When he considers justification, an engineer must consider monetary benefits as well as

intellectual satisfaction for himself, and his employer must be concerned with expected increases in performance of engineering duties.

Many companies have a higher scale of renumeration for engineers with master's degrees than for those with bachelor's degrees at the time of graduation. It may well be, however, that by the time a practicing engineer has completed a master's degree, time will have leveled the salary differences. A company may feel that the master's degree does not qualify an engineer for more salary than he already receives as a result of his experience, but this is usually an exceptional condition.

A practicing engineer with a master's degree should find himself able to grasp new concepts quickly, and this should result in rapid advancement within his specialty field. Although many of the leaders in innovation within the petroleum industry never needed to advance beyond the bachelor's degree level, many began their development as innovative experts with studies leading to master's degrees.

Intellectual satisfaction with the achievement of a master's degree is probably the most difficult benefit to explain. It is almost impossible to show the personal value and satisfaction in completing the studies required for a master's degree in engineering. The pride and self esteem that come with such an achievement have qualitative but not necessarily quantitative value.

There is also a difficulty that engineers should consider regarding graduate studies. Some employers or supervisors may consider a practicing petroleum engineer with a master's degree to be over-qualified for conventional engineering work. It is unfortunate that such attitudes can be present since they fly in the face of technological advancement of the petroleum industry, but this attitude does surface occasionally.

CONCLUSIONS

It is not the intent of this presentation to suggest that all, or even most, practicing engineers should seek to attain the degree of Master of Science in Engineering. Some are simply not qualified for such studies, some would find the effort required for such studies to be too great, and some would gain nothing from graduate studies.

Some engineers can gain immeasurably from studies leading to a master's degree. During the course of their studies, they gain advanced knowledge in mathematics, basic science, computer science, and disciplinary sciences that act as tools for the engineer's trade. The individual's independent thought processes and incentive are enhanced by participation in such studies. The practicing engineer is likely to gain monetarily but is almost certain to gain in the intangible area of professional achievement.

The petroleum industry, in general, and the petroleum companies, specifically, stand to benefit from the graduate studies of practicing engineers. Advanced theoretical and applications knowledge coupled with improved individual developmental work provide an almost indispensable combination for the coming technological improvements that are necessary.