ChE views and opinions

GRADUATE-ENGINEERING AND TECHNOLOGICAL ACCREDITATION

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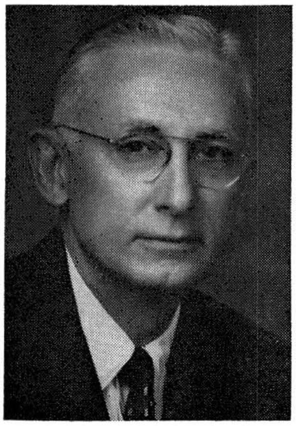

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Perhaps at no time in its history has engineering education been beset by as many problems as exist today. It has been said from many directions that those who left engineering teaching as much as fifteen years ago would not recognize much of the course material taught today. Although this may be somewhat of an exaggeration we recognize its broad validity, and we must look forward to equally rapid changes in the future. A vice-president of one of the great electrical concerns mentioned when talking to students that his company based its long-term planning on the assumption that one-half of its business twenty years from now would be in new products. To transfer this concept to engineering education we might anticipate that one-half of the courses in the engineering college catalogs circa 1985 will be totally new subject matter and the remainder will be considerably altered.

Because college catalogs are revised every year faculties are used to the concept of new courses and curricular changes. The picture of a fifty percent change in course material in fifteen years is not startling because it represents a normal evolutionary trend. In fifteen years the volume of published scientific and engineering material will at least have doubled. There are other changes which are just as probable that appear to produce very severe emotional reactions even when they are merely discussed. Such questions as, what should represent the first professional degree in engineering, and how does technician training articulate with engineering education are highly sensitive areas of interest. These areas require objective anlysis which is difficult to achieve because of emotional reactions based upon the concept of a unified profession that has never truly existed in engineering. We wear blinders if we fail to recognize that technicians continually, although in small numbers, move upward into the engineering profession, and that scientists move laterally with little resistance into engineering activities. Both groups achieve the title of engineer in industry. Engineering is a profession in flux that has still not been defined for the purpose of exclusion either by words or more importantly by actions.

An agency involved deeply with the need to define the undefined and perhaps undefinable profession of engineering is the Engineers' Council for Professional Development. Its task of accrediting engineering curricula and therefore degrees has successfully placed a floor under the profession of engineering that has received broad acceptance. However, this floor, based upon the amount of engineering education that can be mastered in four academic years while allowing for required work in mathematics, science, and social-humanistic studies is not highly restrictive. The great majority of institutions that make an

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effort to recruit an engineering faculty of reasonable quality, who in turn select students of reasonable competency, achieve accrediation. Their products become engineers by definition, and those scientists and technicians who retrain or upgrade themselves to compete with the product of the engineering schools are accepted as engineers.

Under the procedures just described, we seem to have some 800,000 engineers in this country, of which about one-half belong to a major engineering society. A 1967 EJC survey determined that 565,000 individuals belonged to 45 technical and professional societies, of an engineering and applied science nature, of which 438,000 were classified as engineers. The technical societies that hold membership in ECPD and EJC do not all restrict their membership to engineers.

GRADUATE ENGINEERING ACCREDITATION

An old refrain in engineering education has been the five-year undergraduate curriculum. It has been proposed, urged and tried over a forty-year period without significant success. At times it appeared that nearly a majority of faculty members would favor it. Why then has there been so much emotional resistance to the concept of the master's degree becoming the "first professional degree"? It seems doubtful that the resistance rests upon the concept that future professional engineers can attain an adequate education in four years. Such is patently not true. It may be that the terminology of "first professional degree" applied to the master's degree raises the specter that a very large fraction of presently practicing engineers would lose professional status. Because only a quarter of practicing engineers now have master's degrees a long transition period would be inevitable. Terminology can often mask the most desirable objectives.

It is becoming evident that the Engineers' Council for Professional Development is gradually being drawn into graduate accreditation in a step-by-step fashion. The first step over a decade ago was to accredit the master's programs of the Naval Postgraduate School using under-graduate standards. Then a number of master's degree programs or curricula developed in engineering departments having no undergraduate curricula. These departments applied for accreditation and were gradually accepted. Now there are requests for accreditation of master's level curricula in colleges that offer bachelor's degrees in engineering where the bachelor's program is considered to be pre-professional by the institution concerned. ECPD certainly cannot insist upon accrediting a pre-professional curriculum, and it is doubtful that it can logically reject the right of any educational institution to define for itself what it wishes to call its first professional degree in engineering.

The evidence seems to point to the master's degree evolving rather gradually into the main accredited degree whether or not it is called the first professional degree. Important influences are the following: (1) It seems doubtful that a four-year education in engineering can be made sufficiently superior to four years of either science or technology to form the base for a clearly defined profession. (2) An accredited master's degree program based upon student desire and aptitude for advanced study, with the opportunity for those whose interests are not highly professional to accept employment at the bachelor's level, would aid greatly in defining the profession of engineering. Quite independent of emotional reactions this seems to be the most probable direction of gradual evolution. This change will be stimulated by changes in the engineering college catalog because the course material added always exceeds the deletions. Additions can be made at the master's level without gross economic waste due to greater motivation of selected and self-selected students.

A factor that should not be overlooked in the accreditation of graduate education is its usefulness in upgrading the casual offerings at many off-campus centers. Undergraduate work in the evening was at one time taught mainly by industrial employees on a part-time basis. Gradually through the accreditation process evening study has been upgraded to achieve as nearly as practical an equivalency with day curricula and day procedures. At the graduate level there has been a dissemination of degree work to so-called graduate centers. These centers operate not only under the difficulties of evening programs on an over-time basis, but they often use part-time teachers to an excessive degree. Many fail to

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provide even the minimum essentials of library or laboratory resources. Until graduate accreditation in engineering becomes accepted, these graduate centers will lack standards to guide their activities. They need and their students deserve the support that professional accreditation would provide. Unfortunately, we still cannot provide the upgrading through accreditation that the off-campus graduate programs so clearly need.

TECHNOLOGICAL ACCREDITATION

At the opposite end of the spectrum from graduate-engineering accreditation is found the problem of technology curricula accreditation. Beginning with the Wickenden report in the late nineteen twenties it has been recognized that the productivity of engineers depends upon the number and quality of the technicians available as engineering assistants. In World War II the engineering colleges became large scale technician training agencies for the Federal Government and made one of their greatest immediate contributions to the war effort through this channel. A post-war surplus of technicians may have existed for a time, but if so, this could have been only at the lower levels. The United States has never developed an educational system that has produced high-level technicians comparable to those produced in most European countries. Instead, our bachelor degree engineers have performed many technician-level activities.

This country suffers under the status symbol of the bachelor's degree. Parents make great sacrifices for their children to attain degrees. Any degree often appears acceptable. Hence technician curricula ranging from two to three years have never attracted sufficient numbers of students. The result is that new degree-level programs in technology have been growing in numbers. They now represent a considerable group of curricula that carry the same descriptive titles as the branches of engineering, i.e., electrical, mechanical, etc. One technological curriculum widely adopted is building construction, which found a home in colleges of architecture rather than engineering. It has in part superceded the curriculum of architectural engineering which was technically too demanding upon the type of student who was interested in this field. The curriculum of building construction provides the degree incentive and the reward of desirable employment in a status position ultimately directed toward supervision without requiring the rigor of an engineering curriculum. It has grown rapidly in popularity and is entirely outside the control or direction of the engineering profession.

The broad field of industrial technology based educationally upon degree curricula now seems to be ripe for a development comparable to the example given of building construction. The engineering profession can influence this development through its procedures of accreditation or it can stand aside and observe the uncontrolled development of a second channel for the preparation of technological personnel. When this problem was presented by the establishment of associate-degree technician training curricula in the years immediately following World War II it was decided to lend a hand toward strengthening these technical curricula through ECPD accreditation. Of course, the question of terminology arose, in particular the use of the adjective engineering to describe such curricula. Obviously ECPD could serve no function in the field of medical technology or other fields not directly related to engineering. Our interest had to be restricted to the training of engineering technicians. To make this clear the curricula eligible for ECPD accreditation were classified as "engineering technology" curricula. However one may feel about the terminology chosen, the logic involved seems indisputable. Unless a technical curriculum is designed to produce technicians who will work directly with engineers it could hardly fit within the objectives of ECPD.

The recent action of the Board of Directors of ECPD to accredit engineering technology curricula of two, three and four years duration upon the single basis of inspection of about 70 credit hours of technical course work merely fulfills the concept described above. Beyond the required and regulated core of some 70 credit hours the institution may decide to add additional work requirements to justify the award of a bachelor's degree. This additional work may be in liberal arts, business administration, further technical courses in the major, or in a second specialty, or in any combination it may choose. ECPD will restrict its interest to the core program that relates directly to the title of the curriculum. The award of a degree will be primarily the interest of the regional accrediting agency. Regional accreditation at the appropriate level (associate or bachelor's degree) must precede ECPD inspection. It is believed that this limited accrediting procedure by ECPD will eliminate, to the maximum degree possible, confusion between engineering education and engineering technician education.

RECOGNITION OF CONTINUING EDUCATION

The significance of continuing education for engineers was recognized a few years ago by a comprehensive report sponsored by EJC, ECPD, ASEE and NSPE that emphasizes its great importance to the engineering profession. Nevertheless, continuing education operates under the handicap that the achievement of the individual receives no formal recognition. In contrast, a reasonable amount of effort directed toward part-time graduate study can result in a master's degree that receives nation-wide acceptance. If some type of formal recognition of perhaps an equivalent academic year of effort devoted to continuing education could be developed, the attention given to continuing education would doubtless increase. Because of its extensive experience with the accreditation process, ECPD seems to be the logical agency to experiment with this concept of formal recognition of achievement in continuing education. It is hoped that an appropriate channel for such recognition may be devised. It seems to the writer that such recognition is a serious responsibility of the engineering profession that has been neglected merely because of its sensitive nature.

DEFINING A PROFESSION

A profession may be defined in part by required steps of admission and advancement of its members. It can also be defined in part through aiding in the recognition of associated groups, who relate clearly to its activities, but by using distinctly different standards for recognition. Such a relationship exists between engineers and engineering technicians or technologists. There is reason to hope that these and other actions of engineering societies may aid in defining the profession of engineering which has resisted inclusive definition by words alone. Nevertheless, the writer believes that definitions can be improved.

PROBLEMS (Cont'd from p. 221.)

Solution:

(a) Assuming heat capacity effects negligible, use Eqn. (30) in the form

$$\ln \frac{Ka_2}{Ka_1} = \frac{\Delta H^o}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) = \frac{\Delta H^o}{R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$$

From the graph Ka = 0.1 at 427°C and 0.4 at 600°C

Thus $\Delta H^o = \frac{(1.99)(873)(700)}{700-873} \ln \frac{0.4}{0.1} = -9750$ cal/gm mole

This agrees well with the -9810 cal given. The slope of the lnKa vs 1/T plot gives the same result.

(b) At 500°C, Ka = 0.19 for $CO_2 + H_2 \rightarrow CO + H_2O$

For the reverse reaction $Ka = \frac{1}{0.19}$

Therefore, from Eqn. (29)

$$\Delta G^o = -RT\ln Ka = -(1.99)(773)\ln \frac{1}{0.19}$$

$$= -2550 \text{ cal/gm mole}$$

No. 6. The heat of combustion of hydrogen with oxygen at atmospheric pressure and 18°C to form liquid water is 68,300 cal/gm mole H_2O. The reversible voltage for the electrolysis of water in a very dilute acid solution at 18°C is -1.23 volts when all products and reactants are at atmospheric pressure. The latent heat of vaporization of water is 10,500 cal/gm mole, and both this and the heat of combustion vary negligibly with temperature. The vapor pressure of water at 18°C is 15.48 mm Hg (neglect effect of small acid content), while at 40°C the vapor pressure is 55.31 mm Hg.

Calculate the reversible voltage to electrolyze water at 40°C if the products and reactants are at 5 atm pressure. Assume ideal gas behavior and negligible effect of pressure on vapor pressure. For water take the standard state to be (a) pure liquid under atmospheric pressure and (b) pure gas under its vapor pressure at 18°C. Compare the two answers. The reaction is $H_2O \rightarrow H_2 + \frac{1}{2} O_2$.

Solution:

(a) Integrating Eqn. (33) assuming little change in ΔH^o,

$$\left|\frac{\mathcal{E}^o}{T}\right| = \frac{\Delta H^o}{N\mathfrak{F}}\left|\frac{1}{T}\right|$$

or

$$\mathcal{E}^o_{40} = \frac{-1.23(313)}{291} + \frac{68,300(313)}{2(23,050)}\left[\frac{1}{241} - \frac{1}{313}\right]$$

$$= -1.211 \text{ volts}$$

By Eqn. (35)

$$\mathcal{E}_r = \mathcal{E}^o_r - \frac{RT}{N\mathfrak{F}} \ln \frac{a_{O_2}^{1/2}\, a_{H_2}}{a_{H_2O}}$$

$$= -1.211 - \frac{(1.99)(313)}{2(23050)} \ln (5)^{1/2}(5) = -1.2438 \text{ volts}$$

(b) In producing gaseous water ΔH = 68,300 - 10,500 = 57,800 cal/gm mole

Thus, $\mathcal{E}^o_r = \frac{-1.23(313)}{241} + \frac{(57,800)(313)}{2(23,050)}\left[\frac{1}{291} - \frac{1}{313}\right] = -1.228$ volts

Now activity of gaseous water under own vapor pressure is

$$a_{H_2O} = \frac{55.31}{15.48} = 3.57$$

So

$$\mathcal{E}_r = -1.228 - \frac{(1.99)(313)}{(2)(23,050)} \ln \frac{(5)^{1/2}(5)}{3.57}$$

= -1.2434 volts which agrees well with -1.2438