Research & Technology Development and the Exercise of Ethics

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Abstract: Ethics is discipline with what is good and bad and with moral duty and obligation; a set of moral principles or values, or principles of conduct governing a individual or a group (Webster Dictionary).
The paper involves the actors of the technology scenario as doers of R&D and engineering actions and professional ethics. It covers the interfaces between them, the principals of the said scenario for the proper and responsible interchangeable practice in order to forward the technology innovation to its destiny, i.e. to be used in a product or a system that benefits the human society.

Keywords: science, technology, basic design, engineering the technology and engineer.

1. Introduction

Ethics is the discipline with what is good and bad and with moral duty and obligation; a set of moral principles or values, or principles of conduct governing an individual or a group.
Applied Research and Technology Development Scientists and specially Engineers who makes possible the innovated and develop technology to effectively reach industrial production by engineering the innovated technology, should ruled their professional actions through the exercise of ethics and customs imposed by moral, associated to knowledge and responsibility of the doing that should be done in terms of proper accomplishment. In the end they are the ones who innovates, create, develop, build, produce and maintain enterprises and systems for the benefit of society, in terms of enhancing constantly the quality of life of the human being and environment protection.

2. Concepts and Definitions

Science - a branch of study in which facts are observed and classified, and, usually quantitative laws are formulated and verified; involves the application of mathematical reasoning and data analysis to natural phenomenal.

Technology - systematic knowledge of and its application to industrial processes; closely related to engineering and science (1).

Development the work required to determine the best production techniques to bring a new process or a piece of equipment to the production stage.

Whereas applied research pursues technology innovation within laboratory and/or pilot unit scale, technology development means the confirmation of the said innovation in the industrial / commercial scale.

Industrial technology means applied science, that is the exercise of proper application of theories and/or scientific principles, confirmed through experiments in different scales (bench, pilot, prototypes or semi-industrial), to industrial production or to industrial products, and cybernetics systems (opened or closed), patented protected, or not. Thus the expressions: "process engineering", "product engineering" and "systems engineering" which represents respectively the intermediate step to materialize the developed technology into an industrial plant, an equipment and/or machinery or in a macro or minisystem (electrical, electronic, hydraulic, mechanical, etc.).

(I) Dictionary of Scientific and Technical Terms, McGraw-Hill.

Basic Design (process)-- it is a preliminary design that will support a detailed design of a process industry. To execute a basic design means to engineering a technology, already proved in a small scale (bench and/or pilot unit), for an industrial scale with an justifiable economic size.

Technology Package - it comprehends the technology proven in bench and/or pilot unit scale, if possible properly protected by patent and/or patents, associated with the competent basic design in the dimension of the correspondent process industry.

Engineering the Technology / comprehends the execution of the basic design (process engineering) or a prototype design (machinery or equipment), from smaller scales (bench or pilot unit) to industrial dimension. The technical linkage makes possible that the technology developed can be presented by the engineer of the basic design to the possible entrepreneur, with proper data (in the adequate scale for the future industry) needed for a technical and economical feasibility study (cost/benefit analysis) so that the entrepreneur himself might decide to construct, or not, the proposed industry, considering the risks he has to assume. This dialogue would be very difficult to be effective if developed between the technologists (who doesn't know how much will cost the future industry) and the entrepreneur (which decision will depend basically in the cost/benefit of the future industry).

Actually, the industrial/commercial dimension defined by engineering the technology (process or product) is the one which permits the definition of costs, investment s, profitability and return on investment that the smaller scales (bench and/or pilot unit and/or prototype) cannot guarantee. It is valid to remember that the parameters of an industry (process or product) doesn't varies linearly. The steps to be covered by applied research (bench, pilot unit of prototype) they are not covered by caprice or in vain, but above all in the sense to minimize the risks that are going to be taken by the one who will industrializes the technology innovation.

3 -The Actors of the R & D Scenario

The science investigation depends on the ambient where it is performed. It will be mandatory the existence of a special atmosphere that involves the scientists assuring them the liberty to create.

Science itself is inadequate to market demand.

In the other hand technology depends strongly on marketing demand or market pull and, also, from political decision (that was the case of the A-bomb developed during the World War II for political decision).

Applied research pursing a new technology, generally depends on significant investments associated with the capacity of assuming heavy risks by the ones who are developing them. Engineering is market oriented. Its success is heavily dependent upon its capacity to select and absolve technologies (by engineering them) and in some instances (turn-key contracts for developing industrial complexes) to raise substantial amount of money to be invested plus the needed human resources.

The Scientist

The product of the scientist activity is, in general, a scientific paper associated with an oral dissertation. These papers describes physical-chemical and deterministic and/or probabilistic mathematical models created or developed by the scientist itself. The scientific language is normally hermetic; very few persons (generally, only others scientists in the same scientific area) has access to scientific work. Notwithstanding, the wish of the scientist is that his scientific message is received by all the others fellow-scientists. The acceptance of this creativene ss after debating his own thesis with his pairs and its possible disclosure in the international level might be his best reward.

The Technologist

The product of the technologist activity is in geral a report about the physical-chemical and mechanical processes and/or products developed by himself, either in bench and/or pilot unit scale or, prototype. These reports are supported by abacus, diagrams, nomograms, flowsheets, curves, tables, etc. that indicates, within the critical limits of the experiments, the routes, reaction's speeds, energy balances, materials balance, static' s and dynamics loads and other pertinent data that characterizes the qualitative and quantitative aspects of a process, before being industrialized, and/or a product's prototype.

The language of the technologist is less hermetic than his scientist fellow. Its dissemination reaches a much larger public than the one related to the scientist.

Nevertheless, the mentioned dissemination, is rather restricted. The reason for that restriction is associated to the value of the technological product. In the end the innovated technology can create or developed processes and/or products that reaches the consumption market were its going to fight competitors for the share of this market. Being that the assumption, the revealing or disclosure of a new technology is restricted because the technological product has an economic value so it can be marketable.

In the other hand, the technologist, more identified with the economic value of the product that he intends to Seats and developed, has under the aspect of the remuneration and/or share of the commercial results obtained, a very great incentive. In that case, his professional accomplishment is stimulated by his possibility in the development of process and/or products that will be industrialized. As the scientist he will feel gratified in trying to contribute for the society as whole, in its tentative to help to produce goods for the benefit of everyone concerned (and, if possible, of the money returned on the marketable products, patent protected).

The Engineer

The product of the engineer's activity is better known. That will be the case of the basic and/or detailed design and the construction of the industrial enterprise, being a steel mill, and industrial plant, a refinery, a petrochemical unit. On the other hand, he might also execute the prototype design an its manufacture, the production planning of the industry itself and its operation and maintenance, or finally in developing electric and/or electronic, hydraulic, transportation and telecommunications systems.

As the engineer gets away from the interface between the applied research (producer of the technology) and the basic design, going through detailed design, then construction and manufacturing, his professional liberty degrees will shrink because in this last frontier his engineering actions are attached to rigid specifications, standards, methods and procedures, whereas in the frontier of technology development and its engineering has comparatively speaking more degrees of professional liberty.

The engineer is gratified in a wholesome aspect the moment he feels that was the action he has taken that resulted in an undertaking or an machine and/or equipment, engineered by him. The economics sense, its intimacy with cost, the touch of quality, safeties and respect for ecology draws the engineer's profile. He seems to be nearer than his antecessors - the technologist and the scientist - to the sensation of being the artifice more directly responsible for everyone (common) concerned well-being. Actually he had implemented the undertaking and now operates and maintains it.

4. Scientists and Engineers before Professional Ethics

The scientists, in general, identifies himself with the ethics of the reflections, engaged with creativeness and with the nature secrets disclosures, by incorporating new discovering to the society.

In the application of the reflection ethics one cannot asked to the scientist that he worries about the means he uses to reach for results.

On the contrary, he is always dedicated to the objectives of what he is researching, insisting in absolute values.

The imagination is the key that carries one to perceiving and to the changes that permits the science advancements in each of the different fields of knowledge.

It is not rational imaging through pre-determined rules a previous knowledge, of what might happens with a jump that one may give to the future.

The whole society certainly depends on the scientist ingenuity to identify the ways of ones knowledge, that can interpret nature phenomena, facing the unknown.

The ethics of action is associated technology innovation, which is supported by scientific knowledge and consequent actions that conducts the innovation from bench scale to pilot unit and/or product and/or system prototypes, are under the responsibility of the research specialist who produces the technology in a minor scale to the engineer (responsible for engineering the technology).

Who brings it to the larger scale of industrial production (fig.1).

In the other hand, is valid to consider the market demand for improving or modernizing the existent technology, forcing the engineer and his partner, the applied researcher, to go back to the pilot plant (in a scale-down terms) for the proper tests or trials and the consequent actions that leads to an improved technology (in a scale-up terms) back to the market (products and/or services), from where it came, before bring improved.

In the considered interface, a defied ethical problem is associated to the need to bring the technology innovation, developed in the R&D Institutions, to the market for the benefit of the society itself; obviously within cost/benefit relationship, that insures the expected compensation for the venture capital invested.

This implies that the innovated technology must be engineered, considering that the change of scales - pilot unit or prototype - for the - industrial scale - is not necessarily linear, in order that it should be properly absorbed by the production area.

Reinforcing the ethical aspects involved in this process it is mandatory that government money (normally they are largely used, specially in the developing countries, to sustain the R&D Institutions) is efficaciously applied in order that the technology innovation, financed on "fond-perdu" basis, don't moldy in the R&D shelves (most of which are patented protected), impeding, therefore, that they may contribute to improve the quality of life of the communities from where the money came.

To insist upon interfaces between science, technology and engineering we try to examine the critical problem of what would be compatible to the decision makers, being Government or Private, in the decision to what to do, and what to make.

In that case is valid to introduce the so, calls risk ethics, that is the attitudes of the one who decides to follow different ways to accomplished it.

The honest entrepreneur has to face the risk to undertake the problems of cost to do and its return, in to bases of what was billed considering the success of the new enterprise. This success, itself is essential to remunerate the entrepreneur’ s money.

The entrepreneur looks forward for the good relationship between the interfaces abovementioned especially the one between technology and engineering looking for the success of the undertaking.

The entrepreneur validates the basic engineering, specially the technical parameters that are reflected in the feasibility study of the future enterprise. If this study is executed it will give the basic elements for the entrepreneur accept the risks to invest in the new enterprise.

In the other hand the risks to be faced by the "politicos" are presented in other form. In that case the risks to be faced by the politicos are different. The political variables are obviously the ones that the politicos considered. The time factor becomes critical (with respect to the disposed by the politico himself).

Actually the ethics of risks firm the entrepreneur is different from the politico. As far as the entrepreneur is concerned the risk is associated to his money. As far as the politico is concerned the money depends on the government money and on the will of the politico where the risk is associated with its own image (the money doesn't belong to him, nor he responds for it).

Post-Scriptum: As a final recommendation to scientists (applied research) and engineers (basic engineering and/or prototype design), I feel sufficiently authorized to emphasize some more relevant points on the exercise of professional ethics (2).

a) Protect your creativeness or inventiveness, that might be transformed into an industrial property with patent dully registered in the competent office and also try to guarantee in the technology transference contracts the secret trade protection.

b) Do not permit that the technology developed in the R & D Institutions and subsequently engineered come to be implemented (detailed engineering design, civil construction and industrial erecting, followed by correspondents equipment and/or machinery supplies) without the presence of the engineer responsible for the basic design.
c) Use (researchers and engineering designers) the safety coefficients aiming at quality and safetyness of what is going to be built under adequate cost/benefit relationship.
d) Don't omit any linkage on the implementation of the new technology: pilot unit and/or prototype, basic design and the technical and economical financial feasibility study before departing for the detailed engineering design and the subsequent stages of the civil construction and the industrial erecting of the undertaking. (fig. 2)

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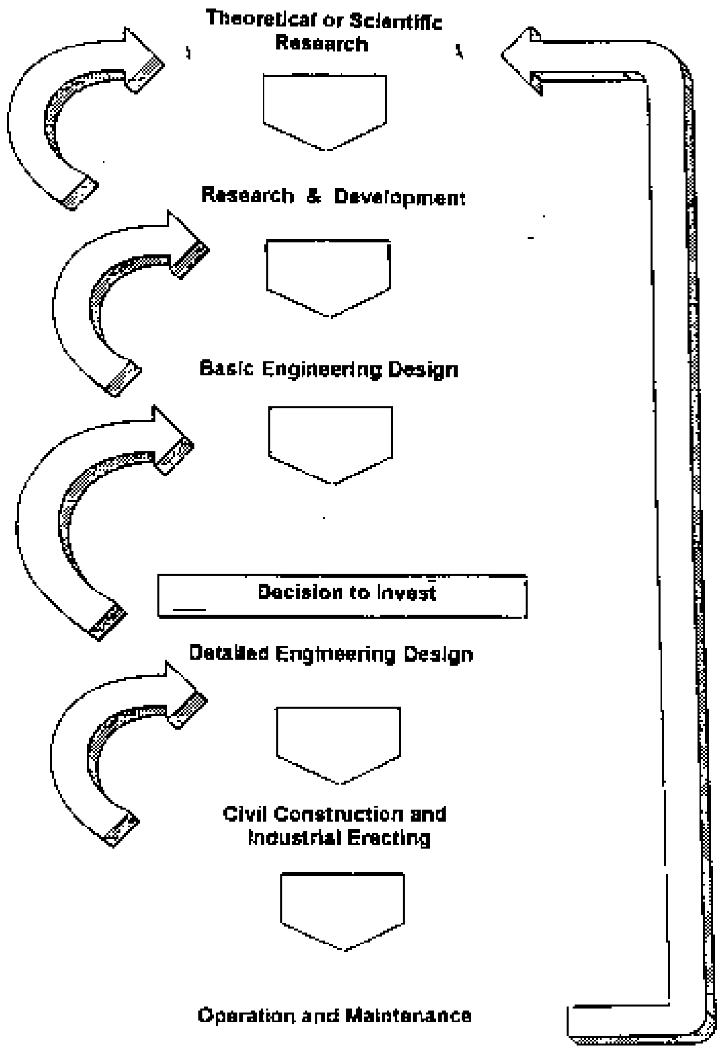
(2) Being for more than 30 years Executive of one of the largest engineering companies in Brazil (more than 800 of engineers) and 10 years as Director of Technology this company, and consultant for several of the biggest R&D Institutes of Brazil such as IPT/ São Paulo State and CENPES/Petrobrás.



Theoretical or Scientific
Research
Research & Development
Basic Engineering Design
Decision to Invest
Detailed Engineering Design
Civil Construction and
Industrial Erecting
Operation and Maintenance

MATRIX DIAGRAM

Engineering activities in a Industrial Complex X
Organizations responsible for its implementation

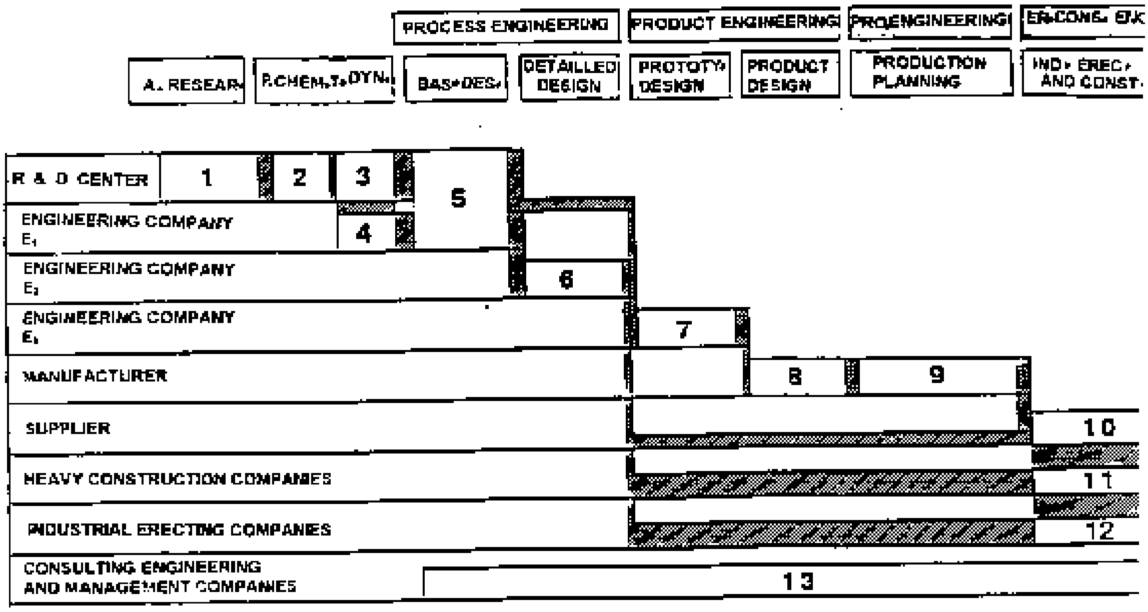


fig. 2

1 - Application of physical-chemical principles and mathematical models

2 - Bench units

3 - Pilot and/or semi-industrual units

4 - Equipment specifications

5 - Flow-sheet, energy balance, material balance. P & I diagram, equipment data-sheet, utilities data Sheet, electrical diagrams, etc.

6 - Civil construction and electro-mechanical installation, inside and outside battery limits

7 - Preliminary drawing, specifications and performance

8 - General arrangement drawings, components drawir specifications, quantities and quality standards

9 - Production planning, special tooling, manufacturin quality control

10 - Procurement, acquisition, inspection and delivery

11 - Civil works

12 - Industrial Erecting

13 - Feasibility, engineering, suplying, start-up and assistance operation