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LOW WASTE TECHNOLOGY IN CHEMICAL INDUSTRIES

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Abstract

The concept of Clean Technologies can be roughly defined when one sticks to simple criteria such as that of production or the treatment of waste, but it becomes highly complicated once extended to other factors such as energy, the environment, ores, heritage, the social aspect etc.

If one keeps to those fields where producers can act in an independent manner real examples show that clean processes do not have special reasons for being more economic than others. Producers adopt processes that prove to be both more economic and cleaner than the processes currently used quite naturally when they are not troubled by problems of depreciation, financing, raw materials, technology, etc.

On the other hand, industry puts officials on their guard against a policy that would tend to lead one to believe that clean technologies are always the most economic and that, consequently, would systematically force industrialists to use these technologies without taking account of economic imperatives.

I was invited to present at this congress a survey of the recent developments concerning "low waste technologies" or "clean technologies", more specifically of technical measures within the framework of these technologies to solve industrial waste water and waste problems, and essentially the development during the last five years as well as expectations for a near future.
I think I am going to disappoint you, first because I do not know exactly what "clean technologies" are, and secondly because I am convinced that the chemical industry has not published the majority of the applications of these technologies. Being the first speaker on this concept, I would like to spend a part of my time to discuss its basis, rather than to give many examples which anyhow will be presented by many of our colleagues this afternoon.
From now on, I will consistently use the designation "clean technologies", and ct as its abbreviation; I further take the view that this designation is synonymous with terms such as "low waste technologies" and "low and non-waste technologies".

"Clean technologies" is a concept which is rapidly gaining popularity. In some countries of the European Communities, public opinion is already grasping the idea, and within the United Nations Economic Commission for Europe, it has been studied for more than four years.It can therefore not be excluded that, some day, industry will have to show that the "technologies" it uses are "clean". A prerequisite is that the concept is unambiguously defined. At this moment, however, the exact meaning of clean technologies is far from clear, and the word is often used in a loose way, suggesting very different implications.
The basic thought behind ct is the idea that "prevention is better than cure". More specifically this means: it is better to prevent the production of waste than to be forced afterwards, to take all sorts of measures to prevent the waste from causing harm to the environment. This will also counteract the wastage of energy and of raw materials.

This basic idea is reflected in a definition of ct which the Commission of the European Communities used in a report to the Council:

> "(ct is) a technique to produce a product with the most rational use of raw materials and energy, at the same time reducing the amount of polluting effluents in the environment and the quantities of wastes produced during manufacturing and during the use of the manufactured product".

This definition suggests the development of techniques which combine an economical use of raw materials and energy with the production of small amounts of waste. As we will show, techniques of this kind are rare, however, and the definition is therefore more idealistic than realistic.

If we take a closer look at the dictum "prevention is better than cure" the question immediately arises: what is the criterion for "better" ? "Better" for whom, or for what ? The above definition of the Commission suggests the following elements as criteria:

- waste ("polluting effluents")
- natural resources ("raw materials")
- the environment
- energy

If we take for a moment all these criteria or elements separately, we arrive at the following set of definitions:

- ct is a technology which produces little or no wastes.
- ct is a technology which makes the most rational use of natural resources.
- ct is a technology which has the smallest possible impact on the environment.
- ct is a technology which economizes energy, or utilizes cheaper, more abundant or renewable sources of energy.

Clearly, concentrating on individual elements leads to very different definitions. Each definition obscures other, almost equally important, elements. Therefore, taking more than one element into account is necessary, but this raises the problem of their relationship.

The consideration of chemical production processes leads to the following basic (and, for a technologist, obvious) conclusions:

- A certain amount of the energy applied in a chemical production process can never be recovered for other uses;
- The production of a certain amount of waste is inevitable;
- It is impossible to isolate the total amount of a wanted product, present in the crude reaction product of a chemical process;
- Each process has its individual characteristic relationship between raw material, energy, wanted product and waste.

These conclusions have an important consequence. It cannot be stated as a general rule that, if production process B yields less waste than process A, B will also consume less raw materials as well as less energy. This type of relationship is even very rare. On the contrary, when comparing three chemical processes for the manufacturing of the same substance, it is almost a normal situation that, e.g.:

- one gives a high yield of a very pure end-product, a small amount of non-recyclable waste and a high consumption of energy;
- the second one a reasonable yield of the end-product, a reasonable consumption of energy, but a fairly large amount of non-recyclable waste;
- the third one a rather low yield of the product, a reasonable consumption of energy and a rather high amount of recyclable waste.

Which of these three processes should now be called "clean" ? It is clear that this question can only be answered if we weigh the various pros and cons, and come to a balanced overall view.
Economic aspects shall have to be included in this balance (at this place we should like to observe that these aspects are not mentioned in the Commission's definition of ct).
From what I have said it is clear that I find great difficulty in deciding what ct exactly is.

In publications on ct it is often argued that, when the production of waste in a process is inevitable, this waste should be re-used or recycled to make the process cleaner. One basic statement can be made:

the addition of a process for the re-use or recycling of waste to a technology requires:

. extra investments
. extra labour
. extra energy.

Whether these expenses can be recouped by the revenues of the re-used or recycled waste depends entirely on the individual case at hand. In many cases the economic result will be negative.

In considering the application of the concept of clean technologies to industrial production, a down-to-earth but basic fact-of-life should never be forgotten. In our economic system industry is subject to the law of competition,

and as a consequence every producing unit has to struggle for minimum production costs. It can therefore be stated as a generalization that

- when, in producing a certain product, it is technically feasible and economical to consume less resources or to produce less waste, this is done so already;
- when this is not done, it is either technically unfeasible, or uneconomical, or both.

Exceptions to this rule are caused by:

- serious management errors;
- lack of sufficient incentive to go the way of ct;
- lack of sufficient resources for research, development and investments (this specifically applies to the middle-sized and small enterprises !);
- the present use of installations that have not yet been sufficiently depreciated;
- the time necessary to develop a new technology to production scale (which may take from five to ten years after the initial invention);
- safety requirements (example: the process used in the rebuilt Flixborough plant).

The resulting industrial activities to implement ct are essentially pragmatic, directed towards very specific problems and reflective of internalised cost factors. The majority of these activities result in adaptations of existing processes, the minority in entirely new processes. Most of the adaptations or new processes are never published, because they are considered as a highly confidential part of the know-how. This is one reason why it is almost impossible to give a satisfactory survey of the industrial development of ct during the last few years.

In our considerations, we have now arrived at a crucial point. In our economic system industry is manufacturing products under the constraint of:

- a continuous competitive position (which means: the production of marketable products at a competitive costprice)

with the following boundary conditions:

- the legislative framework;
- the need for the continued existence of a producing plant;
- the need for acceptance by society.

This constraint and these boundary conditions put strong and effective limitations on the freedom of an industrialist to act. They are particularly evident in questions concerning the requirements of society.
We think of questions such as:

- what will be the costs to society after the waste has been disposed of ?
- do the real costs of the raw materials or energy adequately reflect the forthcoming depletion of these resources ?
- what will be the environmental harm of the production process and of the waste ?

I should be realized that, from an economic point of view, there is a basic difference between the cost aspects of these questions and the aspects which are normal elements of the costprice of a product (investment costs, depreciation, labour costs, costs of raw materials and energy, etc.). If we call the costs to society of the production process involved "social cost", and the others "costs inside the fence", then it is a factual statement that:

"costs inside the fence" are borne by the production plant,
"social cost" by society*).

"Costs inside the fence" can and will be minimized by the plant; and so can "social cost" in theory, but in our economic system a plant doing so would put itself in a highly vulnerable competitive position. "Social cost" can only play its proper economic role if appropriate government measures make it internal for all competing producing units concerned. These measures are political decisions, however.

Stated in a general way:

- internal costs are the concern of industry;
- "social cost" is the concern of society.

Society, and not industry, should discuss what political decisions will have to be taken concerning "social cost"; industry's role in this debate is to show what the consequences of the contemplated political measures will be.

The same applies to considerations about the environmental impact of the manufactured product, with questions such as:

- what will be the environmental harm of the product during use ?
- what will be the costs to society for the disposal of the product ?

For a manufacturer questions like these are to a large extent "outside the fence". He tries to influence some of them by issuing safety data sheets, instructions for use, packing, labelling, etc., but this influence and control, once the goods are outside the fence, are limited.

The inevitable conclusion is that a manufacturer can only adopt a clean technology if this does not prevent him from maintaining a competitive position. Or, in other words:

a manufacturer has to take so many factors into account in considering possible changes in production processes that to him a beautiful dictum like "prevention is better than cure" or "make production processes cleaner" hardly makes sense. A manufacturer can never adopt a cleaner process only because it is cleaner !

In the foregoing, I have come to the following conclusions:

- a definition of ct as a technology which combines the production of little waste (or the recycling of waste) with the economical

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*) This statement should not be misunderstood. It does not mean to say that industry is indifferent to things which happen "outside the fence". Serious social consequences of its activities are industry's concern, and there have been many instances where industrialists have taken voluntary steps to end the use of certain chemicals for some applications where they were found to be dangerous.

use of raw materials and resources as well as with a profitable result, is idealistic rather than realistic;
- a manufacturer can never adopt a cleaner process only because it is cleaner; he has to base his decision on the economic viability of the process.

Let us therefore now have a look at the actual situation of ct, and more specifically consider in what sense the designation "ct" is really used. Most active in the promotion of the industrial application of ct has been the government of France. It has developed a legal framework which is described to consist of

- compulsory environmental standards for every plant;
- environmental standards for sectors of industry;
- financial support for the development of techniques and the installation of equipment necessary to produce in conformity with these standards;
- levies to finance this support.

In France, ct is further promoted through

- support of research activities;
- organization of flow of information on ct processes;
- financial incentives for ct investments.

Looking more carefully at all these measures, it becomes clear that they consist of the "normal" environmental legislation, as found in every industrialized country. However, based on the dictum "prevention is better than cure", almost every adaptation of an existing process to produce (somewhat) less waste, or almost every production process that recycles (part of its) waste, seems to have been baptised "ct" in France. This is illustrated by a few examples:[1)]

- recovery of methionine from mother lyes by evaporation;
- recycling of the effluents from glue and gelatine manufacturing;
- incineration of primary sludges from a kraft paper pulp factory;
- oxygen bleaching of kraft paper pulp;
- treatment of refinery effluents with recovery of hydrocarbons;
- treatment of wash waters from a quarry with recovery of sand;
- incineration of chlorinated residues with recovery of hydrochloric acid.

In my opinion, the designation "ct" of these processes shows that this word is merely used here as a fashion word.

The Dutch government provides subsidies for the development of ct; according to a brochure, they consider the following projects to be ct:

- recuperation and re-use of heavy metals from waste streams;
- reduction of the emission of sulphur dioxide and nitrogen dioxide from combustion installations;

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1) Taken from the (popular) booklet "Usines propres. La technologie au service de l'environnement", published by the French Ministère de la Qualité de la Vie (La Documentation Française, 1975). This booklet contains 24 examples of recuperation and re-use of wastes.

- purification of waste water containing organic impurities, using e.g. anaerobic digestion.

Again, these examples show the very "loose" meaning of the designation "ct".

In Germany, DECHEMA (a society of companies active in the field of the construction of chemical equipment) has published a nice booklet[1] with the detailed technical examination of 15 chemical examples of ct:

- sulphuric acid, double contact process;
- nitric acid, reduction of NO_x emission;
- electrolysis of sodium chloride, a reduction of mercury losses;
- production of sulphur using the Claus process;
- ethylene oxide via the direct oxidation of ethylene using oxygen;
- aluminium electrolysis, reduction of the emission of fluorine compounds by dry purification of exhaust gases;
- recycling of fluorine compounds in the production of phosphoric acid;
- recycling of waste hydrochloric acid;
- recycling of waste sulphuric acid;
- recycling of waste gypsum;
- production of aluminium oxide from bauxite, re-use of red sludge;
- recuperation of solvents;
- optimizing the energy balance in the production of sulphuric acid;
- calcination of aluminium hydroxide: fluidized bed process;
- synthesis of ammonia, steam-reforming process.

The common designation "ct" for all these processes seems no more than giving them a nice fancy label.
Of the other ct activities, the following should be mentioned:
The United Nations Economic Commission for Europe (Geneva) (ECE)[2] has been active in this field since 1975. Initially, they designated "ct" as "non-waste technology", which later developed into "low and non-waste technology and re-utilization and recycling of wastes". One of their most tangible actions was the sponsoring of a one-week seminar held in Paris, November 29 - December 4, 1976. During this seminar an overview was given of the concept and principles of ct, the state of ct in a large number of countries (the Netherlands, Canada, Austria, Poland, UK, France, Hungary, Sweden, Belgium, Finland, USA, Germany (FR) and Yugoslavia), industrial experiences with ct (including case studies from the iron and steel, pulp and paper, packaging, and tyre industries), cost/benefit aspects of ct, ways and means of implementing ct and methodological and strategic aspects. Despite the broad coverage of the more theoretical

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1) Dr. J. Wiesner, Umweltfreundliche Technik. Verfahrensbeispiele Chemie. DECHEMA, Lehrprogramm "Chemie und Umwelt". Frankfurt (M), 1977.

2) ECE has defined ct as: "the practical application of knowledge, methods and means, so as - within the needs of man - to provide the most rational use of natural resources and energy, and to protect the environment". In my opinion this is much too vague a definition to be practicable; moreover, cost aspects are not included.

contributions, the practical examples of ct processes are almost without exception, re-use and recycling processes for wastes.
The proceedings of this seminar have been published by Pergamon Press [1].
Further to this seminar ECE has taken the initiative to compile a compendium of ct processes. National focal points will collect examples of these processes, which will be described in monographs in a standardized way and made available to the governments of ECE member-countries. ECE also has a committee (consisting of government experts) that develops methodologies for comparison and evaluation of various clean technologies.
ECE has organized a "high level meeting on the protection of the environment"[2], in November 1979. One of the main topics on the agenda of this meeting was "low and non-waste technology and re-utilization and recycling of wastes". The result was declaration on the actions to be taken, nationally and internationally, to promote ct.
The Council of the European Communities has emphasized the importance of "the development of less polluting ways of production" and of "the beneficial use of the resulting by-products". The Commission of the Communities is now making a comparative analysis of the research and development policies on ct in the Member States; this will ultimately result in regulations to support and stimulate these activities.

If we compare all these activities and all these examples with the definitions of ct given, the conclusion can only be that, at this moment, ct is used as a fancy word with no other meaning than "technologies that are friendly to the environment" or "production processes that are environmentally sound and appropriate".
But the involvement in ct of authorities and the public at large, then, is not different from the attitude towards the environmental issue as it has developed since the late sixties; it is just another logical step forward, characterized in a loose way. For industry this means that it should continue to accept its environmental responsibilities in the same way as it has done before, adding the dictum "prevention is better than cure" to the numerous peripheral conditions that have already to be met by its activities.
Industry will develop and implement this concept, aware of its economic and social responsibilities, and this will form industry's most important contribution to clean technologies.

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1) Non-Waste Technology and Production. Proceedings of an international seminar organized by the Senior Advisers to ECE Governments on Environmental Problems on the Principles and Creation of Non-Waste Technology and Production. Paris, November 29 - December 4, 1976. Pergamon Press for the United Nations. 1978.
2) This is a meeting at ministerial level within the framework of the Final Act of the Conference on Security and Co-operation in Europe (Helsinki, August 1st, 1975).