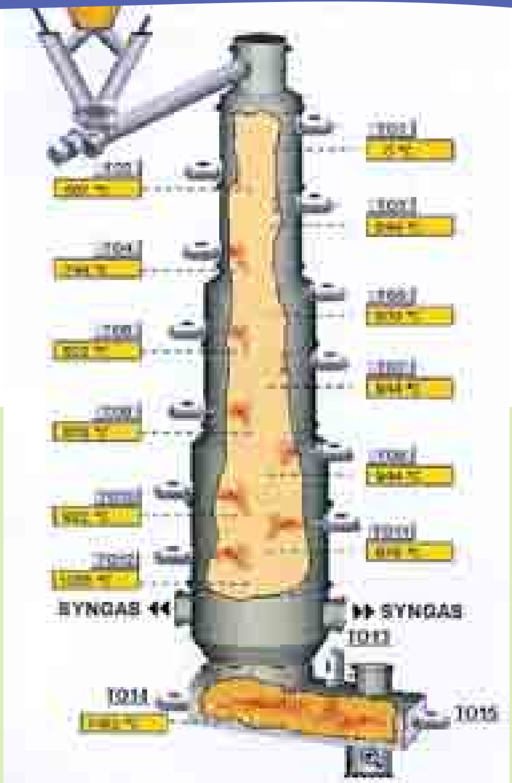


Waste incinerating plant

Gasification technology

OLIVIER

OLIVIER GROUP is exclusive dealer for

ATS GROUP

HYDROGEN: WHAT FUTURE?

The energy industry, from now on and more and more in the future, in particular in the next 50 years, will have to reconcile two contrasting demands: the growth of energy request at worldwide level and the correlative increase of environmental impact both at global level, such as the greenhouse effect and the change of the climate, and at local level for the air quality.

The developing countries, with particular regard to China and India, will try to carry out their natural aspiration to reach economic growth and life good quality levels like the industrialized countries with the consequent increase of energy needs. Such increase will assume significant values in relationship both to the swiftness of the predictable development and the growth of the pro-capite consumption of energy (the only China grows more than 10 millions people every year). Furthermore, if the rest of the world reached a pro-capite consumption of energy equal to the half of the average of the OCSE Countries, the worldwide energy needs would double and in proportion, without substantial structural changes in the energy system, would increase the emissions by tragically worsening the quality of life with irreparable damages both to health and ecosystem. These simple considerations give an indication how the necessary energy production is important and difficult for the "tolerable development" which should allow to provide an adequate quality of energy to the worldwide population, in consideration of its growth, reducing the difference between rich and poor countries, it should allow to use the exhaustible energy resources with respect of the inter generation equity, ensuring an adequate availability also to the next generations and to produce and use the energy with reversible environmental impact or however tolerable by the ecosystem.

The recent Kyoto international conference discussed these problems coming to an agreement which takes up the developed countries and the economies in transition phase to reduce, in 2010 the greenhouse gas emissions of about 5% in comparision with those of 1999.

This agreement, which has not however been ratified yet by most signatory countries, has had the merit to promote concrete initiatives to start interventions on a big scale for the restriction and the reduction of greenhouse gas.

The interventions regarded and concern the most rational use of the energy, the efficiency improvement of both the energy processes and the production technologies and use of energy, which have quickly given interesting results, which in perspective, also in short time (about 10 years), will run out the waited benefits, dramatically reproposing the problem of the socio-economic development and total pollution.

There is a solution, and it is just one: to introduce the hydrogen as energy vector!

Hydrogen is, in fact, besides the electric energy, the only not polluting, accumulative, easily supplying energy vector and which can be produced by several energy sources, the renewable ones included.

The hydrogen represents the key component of a new tolerable energy system: it can be produced by the fossil fuels, subject to conversion of the same ones with mature technologies (steam reforming, partial oxidation, gasification) and advanced technologies (membranes reforming, pyrolysis processes with carbon separations, without carbon dioxide production) and CO2 separation allowing

the cleanest way to use these fuels. Furthermore it can be produced by other sources (renewable, nuclear) without CO_2 emissions and during its use it does not generate either CO_2 nor other types of pollutants, satisfying other fields which go from the generation of electric energy, to transports, to the most disparate uses in the civilian and industrial sector.
In perspective, in accordance with the more credited forecasts (OECD, DoE, Iaasa and the most important oil companies) the energetic market will be dominated, within 2020, by the natural gas which assures the lowest enviromental impact (lower CO_2 production) in all the energy conversion processes thanks to the optimum hydrogen/carbon ratio (4:1). Despite this forecast, the growth of the energy consumptions at worldwide level and however the necessity of the developing countries to use the plentiful coal reserves for their growth, makes the stabilization of CO_2 at a middle level of 550 pmm within 2050 necessary. The evaluation and the economic advantage is fundamentally based on the "avoided" CO_2 cost and on the awaited benefits from significant savings in all the sectors, which nowadays require interventions of "environmental improvement". A study of the U.S. Department of Energy assumes a cost of about 15-25$/t for the CO_2 seized by the hydrogen production process and one of about 300$/t for the separable one from the smokes of the current works and energy production processes.
Therefore it is possible to tolerate the background in which the hydrogen, however produced, can be distributed by a suitable pipe-line, accumulated and used for all the energy applications, the transports area included.
When the hydrogen is produced by fossil fuels, the separate CO_2 is bordered in stable way in the subsoil of the saline waters at about 800/1000 meters depth or in methane or petroleum worked-out deposits (a confinement below sea level, beyond 1000 meters, in particular streams and thermal gradient conditions, is also assumable).

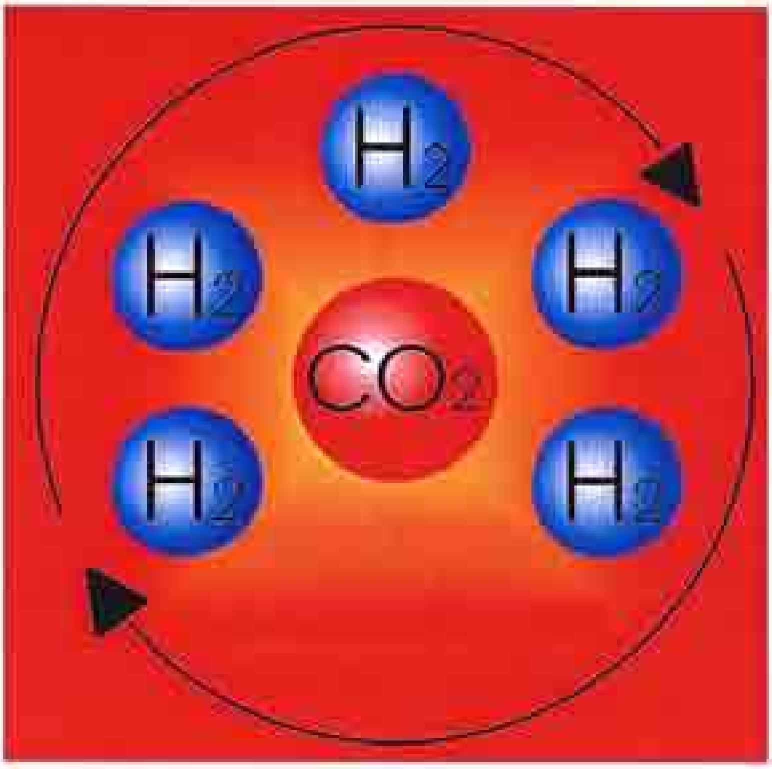
The optimum use of hydrogen is since today insured by the technology of the fuel batteries which guarantee high conversion efficiency (60% in electric energy, and up to 75% with the thermal recovery through a turbine).
The fuel batteries usually called fuel cells, which have reached a good development level, are fit also for all the applications both for the centralized and the distributed generation, by keeping a high conversion efficiency without being penalized either by the size of the power or the change of the work charge, and for the use in the electric transports without environmental impact.
A national program is in advanced arrangement phase by Enea (National Council for Research and Development of Nuclear and Alternative Energies) and by Eni (National Hydrocarbon Agency) through a combined study. Even if the main interest of Eni is turned to the hydrogen production from fossil fuels, Enea will extend the program to the renewable sources applications and to the ecosystem behaviour evaluations as well as to the research and the development of advanced technologies and processes (hydrogen store, in carbon nanostructures, solid membranes for CO_2 separation and the purification of the hydrogen for polymeric membranes fuel cells, application to the transport means, etc.) and to the solution of the problems of safety and standardization concerning the hydrogen use.

Written by:

Carlo Rubbia and Raffaele Vellone
Prof. Carlo Rubbia, Nobel prize winner for the Physics and Chairman of Enea
Dr. Raffaele Vellone, director of the Department and Advanced Energy Technologies of Enea and responsible for the Enea-Eni Hydrogen National Project

From "La Termotecnica" - October 2000

WR: Waste Remedy



A SERIES OF HIGH TECHNOLOGY PROCESS AIMING TO THE ENERGY PRODUCTION WITHOUT EMISSIONS

The never well definite frontiers of the so-called "tolerable development" clash every day with the growing need of clean energy and with the necessity of removing all substances not reusable in processes they were produced from, too much generically called wastes and treated in processes using more or less polluting technologies.

"A tolerable development strategy requires a stronger increase in value of that big resource which is knowledge.

The nature itself is the primary source of knowledge. Mankind learned the knowledge to use up to unsustainable levels from nature itself. Now mankind can learn how to progress respecting the limits. However how not to see the high potentialities of the technological innovation, the possibilities of multiplying the ecoefficiency, to develop renewable and clean energy and sources, to stop pollution, to drastically reduce the consumption of natural resources, to live better and with more and reasonable wealth, in peace with nature?

Knowledge, opportunely oriented and spread, can become the principal engine of the tolerable development: a clean engine fed by a renewable energy"[1].

WR suggests as objective to realize a process that allows, starting from raw materials coming from wastes, and usable in any industrial or civil activity without further atmospheric pollution production, to produce hydrogen (H2), recovering carbon dioxide (CO2).

[1] From "Uno sviluppo capace di futuro", Edo Ronchi, Il Mulino

INCINERATORS OR THERMAL "EVALUATORS"?

It rises spontaneous the question why in the high technology era the problem of the correct treatment of waste, both of civil or industrial origin, has not found the right solution yet.
The costs of waste disposal are very high, the treatment plants which are installed require big investments without definitively solving the initial problem: POLLUTION.
In the last few years the most important evolution of the incinerators, pointed out in the specialized congresses or in specific sector reviews seems to be stopped at the fact that now they are called "thermal evaluators". Anyway they are incinerators even if they can boast some more per cent point as energy performance and a few additional equipment, which limits from one side the emission of dioxins and other polluting gases, creating perhaps other problems from the other one.

Thermoevaluators in Brescia - Italy

The first answer to the initial question emerges in a very clear way:
When the initial concept is "WASTE DISPOSAL" all the initiatives followed up to today find a justification. The principal aim is to destroy, the secondary aim is to limit the damages of this destruction, the third aim is to decrease the destruction costs, by recovering energy. And this is a progress in comparision with the burial in dumps, a method which was very used in is the past and unfortunately too much used in the present. It must be remembered that attempts have been done and are trying to solve the problem, also through different systems, but unfortunately the dominating "WASTE DISPOSAL" concept conditions and determines the adoption and the results of the applied alternative technologies.

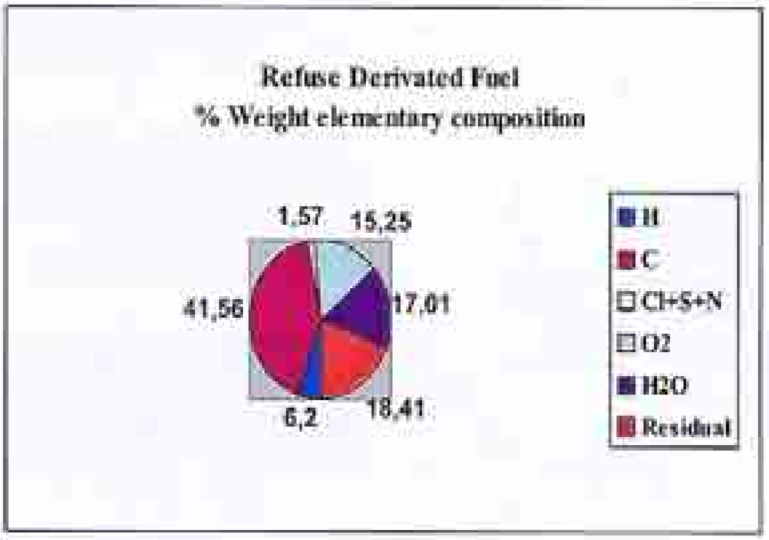
WR: A NEW "WASTE DISPOSAL" CONCEPT

WR starts from a different concept. **The aim is to produce.**
The choice of the product is determined by four factors:

- the market request
- the availability of the starting raw materials
- the economic costs-returns production budget
- the production social cost bound to the "sustainable development"

➲ The first question finds an easy answer in the editorial proposed in the first pages of this presentation: aim "HYDROGEN PRODUCTION".

➲ The second question inevitably takes to the rediscovery of all presenting everything, in part at least, hydrogen and carbon contents, simply called waste up to now. This is for WR a precious and indispensable raw material, whose availability is very high.



➲ Any productive activity, being nowadays undertaken, cannot leave the economic costs-returns evaluation out of consideration.
In a few cases, above all when the worldwide ecosystem future could be involved, this evaluation should be subordinate to many others, but actually nations are driven by economic laws at first and then by all the rest, where ecology is not either pre-eminent.
For this, WR's aim is to provide a product that, on the basis of the current values of conferment of the raw materials and the return value from the use of hydrogen, can guarantee an acceptable return of the investment (8-10 years) and, can reach, with the scale optimizations, also the reduction of the value of conferment and consequently of the economic and also environmental benefit for the citizen.

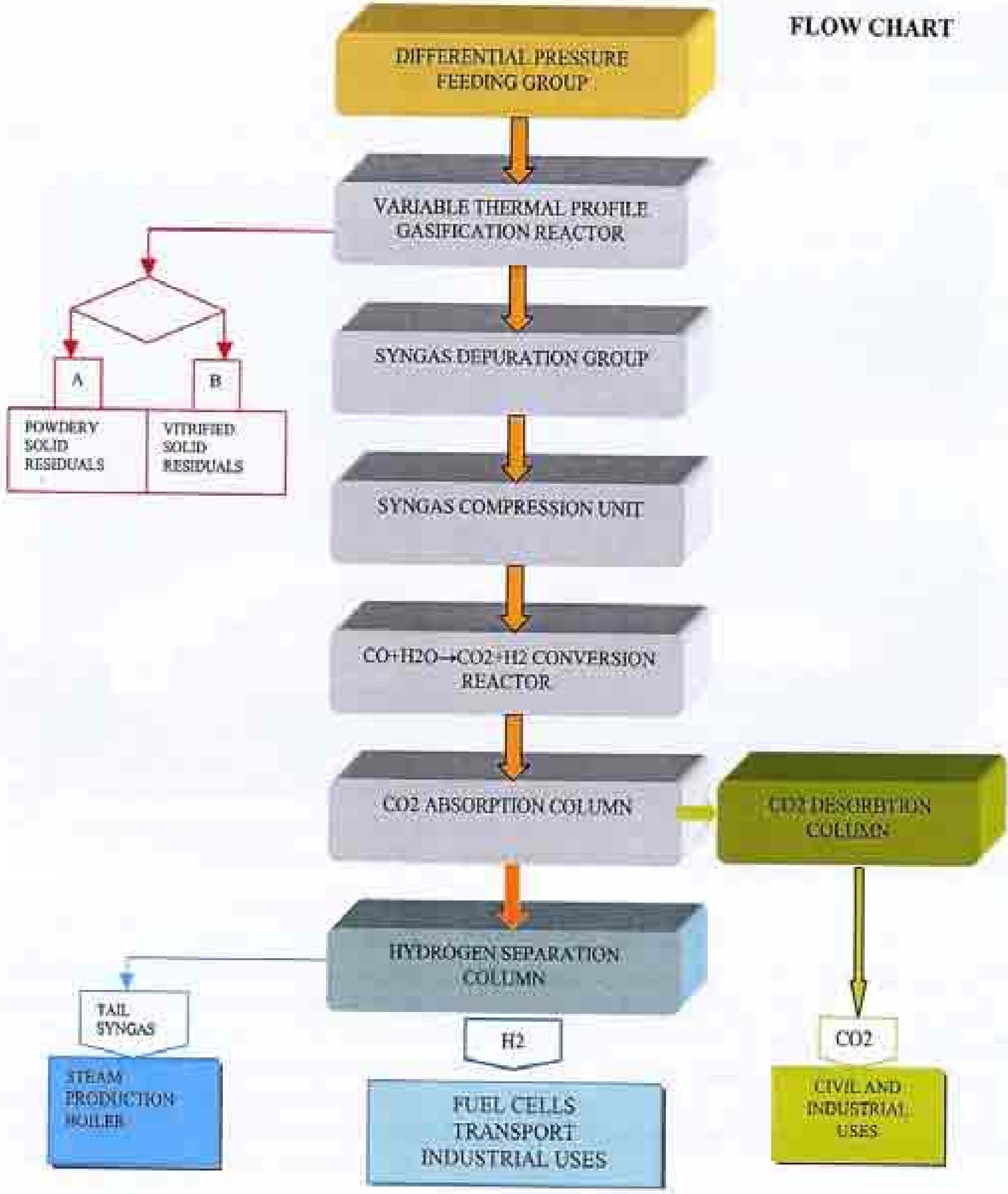
➲ It would be inconceivable and it could not be proposed that the realization of a plant which, having as purpose the solution of a social problem, creates in the same time some other problems with worse consequences than the starting problem.
We could decide to stop the progress in the name of the "SUSTAINABLE DEVELOPMENT".
WR proposes the remedy and the wastes problem solution through the realization of a transformation process which does not produce emissions: NO POLLUTION.

OLIVIER

WR: THE TECHNOLOGICAL SOLUTION.

AIM: hydrogen production starting from raw materials (at present called wastes) without producing pollution.

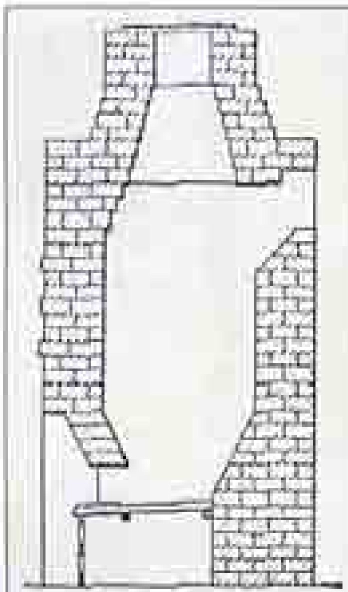
SOLUTION: gasification of raw materials with purified syngas production (at high hydrogen concentration), final reaction and hydrogen separation, with carbon dioxide recovery.



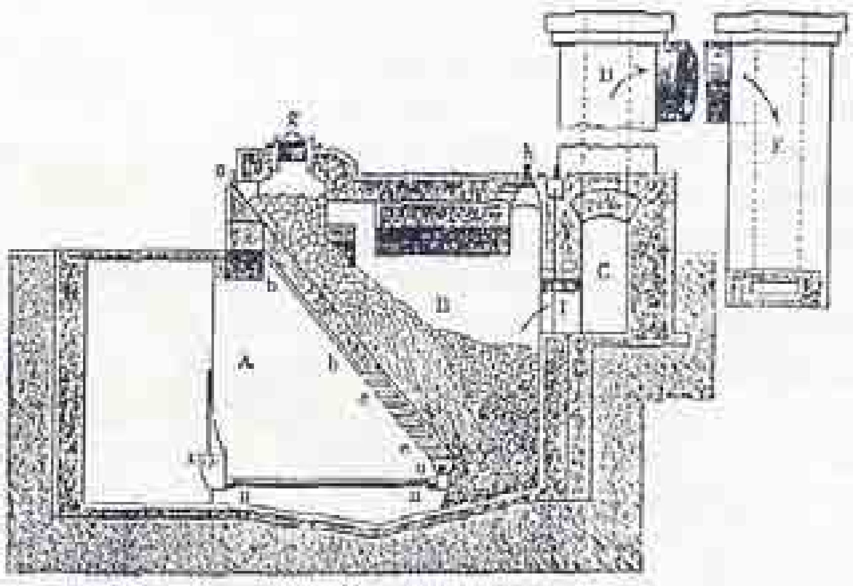
WR: THE GASIFICATION

The pyrolysis or gasification process is a chemical decomposition process exclusively produced by the thermal energy intervention. In absence of air (and oxygen in excess), and so in reducing ambient, the gasification causes the organic thermochemical decomposition of the organic material. The process, endothermic for its nature, causes the resolution of the complex molecules which constitute the fed raw materials, turning it into a gaseous uncondensable (syngas) phase principally composed of hydrogen, carbon monoxide, nitrogen, carbon dioxide and secondarily, in very low percentages, of chlorine, sulphur, fluorine and metals, which are possibly contained in the fed raw materials.

The gasification has been a well-known technology for a long time, the first known applicatory examples date back about two centuries ago. (See pictures1 and 2).



Picture 1 - Gas-producer of Bischoff (1839)



Picture 2 - Gas producer Siemens (Prussian patent 1856)

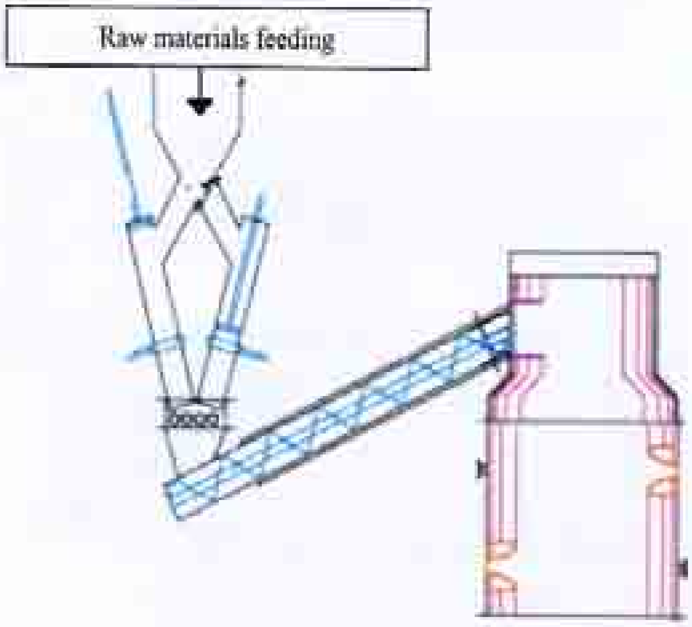
Since then of course steps ahead were taken and this technology has found, and still finds, many applications with excellent results in the chemical and petrochemical industry, that is where for usual procedure the reactions are led and managed with the specific aim at producing this or that molecule.
The results obtained with the gasification of wastes are different, generally quite unsatisfactory and only in few cases acceptable.
The use of this technology with the principal purpose of "waste disposal", by using equipment more like huge "pans" than specific reactors, could not help but reaching these results even calling into question the possibility of application of the gasification itself.

WR: THE FAST GASIFICATION REACTOR

The reactor for the fast gasification is composed of three sections which are an integral part of the same one. The first section is constituted by a raw materials differential pressure feeding system; the second section is constituted by the variable thermal profile fast gasification zone; the third section is constituted by the system of extraction of the gasification solid residual extraction system.

1 RAW MATERIALS FEEDING SECTION

The feeding and the dosage of the raw materials has fundamental importance for the realization of the fast gasification process. In fact, the continuity of feeding, the size of the fed solid material and the realization of the feeding differential pressure turn out to be very important as blockage system to avoid the penetration of the ambient air inside the gasification reactor.

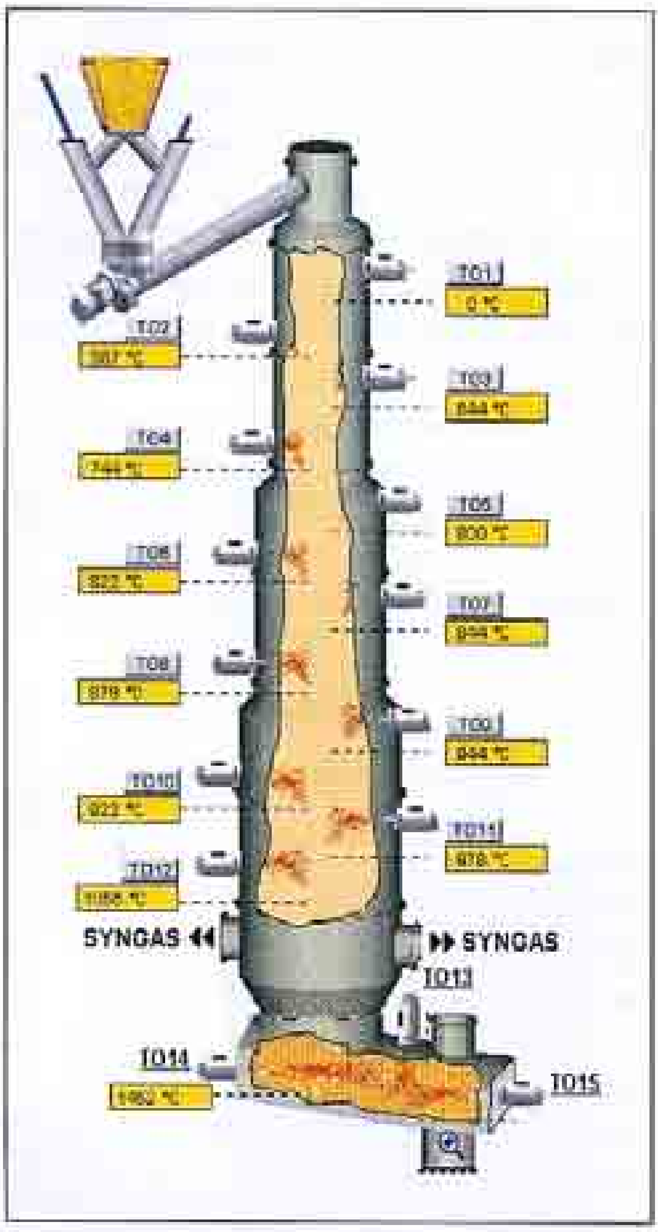


Reactor: Feeding section

The feeding is developed in four different phases:

- compression for mass loaded raw materials
- introduction and dosage through pressure push pistons
- controlled size grinding
- fluidification and feeding to the gasification section with possibility of preheating

2 FAST GASIFICATION SECTION



It is a vertical development monotubular reactor with descending current.

This reactor section is designed to realize the fast gasification reaction in continuos. It is composed of a series of cylindrical sections with different diameters put one on the other (on every section a couple of torches is positioned at least, set at about 1 meter one from the other) with its thermometric survey: the number of the couples of torches depends on the diameter and length of the section and on the capability of the plant. The torches are fed with oxygen, as comburent, and with the available gaseous fuel (methane), dosed at stoichiometric ratio.

The realization of the monotubular reactor in cylindrical sections equipped with the opportune frustum-conic tapers, which allow them to be one on the other also in presence of various sections, allows a building modular structure and the possibility of making them transportable also with the refractory covering being already installed.

This characteristic materially allows to reduce considerablythe assembly time at the yard also for the reactors with the maximum admissible flow rate (10t/h), because all the parts of the plant can be assembled in workshop and then transported and, definitively assembled, at the final destination place.

The advantage of this solution is due to the fact that by completely making the various building phases in workshop (mechanical framings, refractory linings), and not bindingly at the yard, the quality of the work turns out considerably improved, the building costs decrease, the time of realization is much shorter. Besides the building modular structure allows the availability of spare sections in the workshop, making possible and convenient the replacement of a damaged section with the spare section, reducing the time of plant stop with a great advantage for the productivity.

In the first cylindrical section, placed to the top of this gasification area, on one side the opening is made for the connection to the screw which transports the ground raw materials coming from the feeding section. The reactor can be equipped with one or more feeding sections in order to gasificate, simultaneously, various raw materials which are physically different, and for security or process reasons, not mixable among them.

2.1 REACTION TEMPERATURE

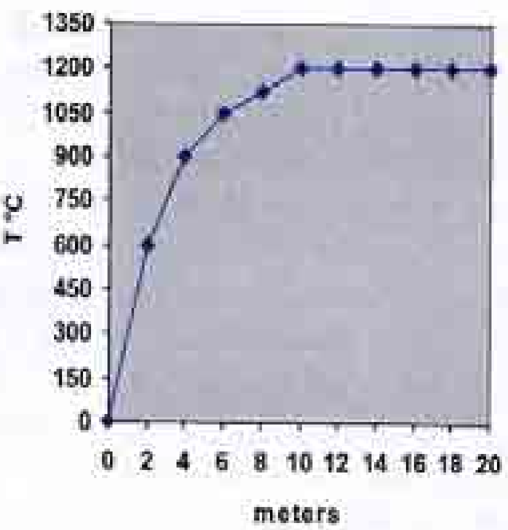
The reaction temperature is variable according to the single zone of the reactor and the typology of the fed raw materials. The admitted temperature range, in the gasification section, starts from a minimum of 350°C, to a maximum of 1200°C. The exercise temperature in the various zones of this section is determined through a setable VARIABLE THERMAL PROFILE in the admitted temperature range.

The trend of the thermal profile is determined by the typology of the fed raw materials or possibly by the mix of the same ones according to the amount of the present water, of the amount and of the typology of inorganics which are present, of the granulometry and in consequence the reactivity of the fed raw materials.

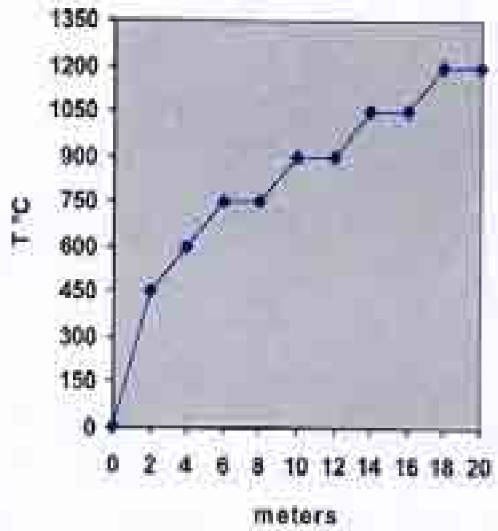
In a few cases it can be necessary to set up a thermal profile tending to reach the maximum temperature in the minimum possible time (see graph 1), while, in other cases, it can be more convenient to reach the maximum temperature only in the final part of the gasification section (see graph 2).

The two thermal profile examples for the gasification section, assumed with a length of 20 meters, are the following ones:

Thermal profile: Graph 1



Thermal profile: Graph 2

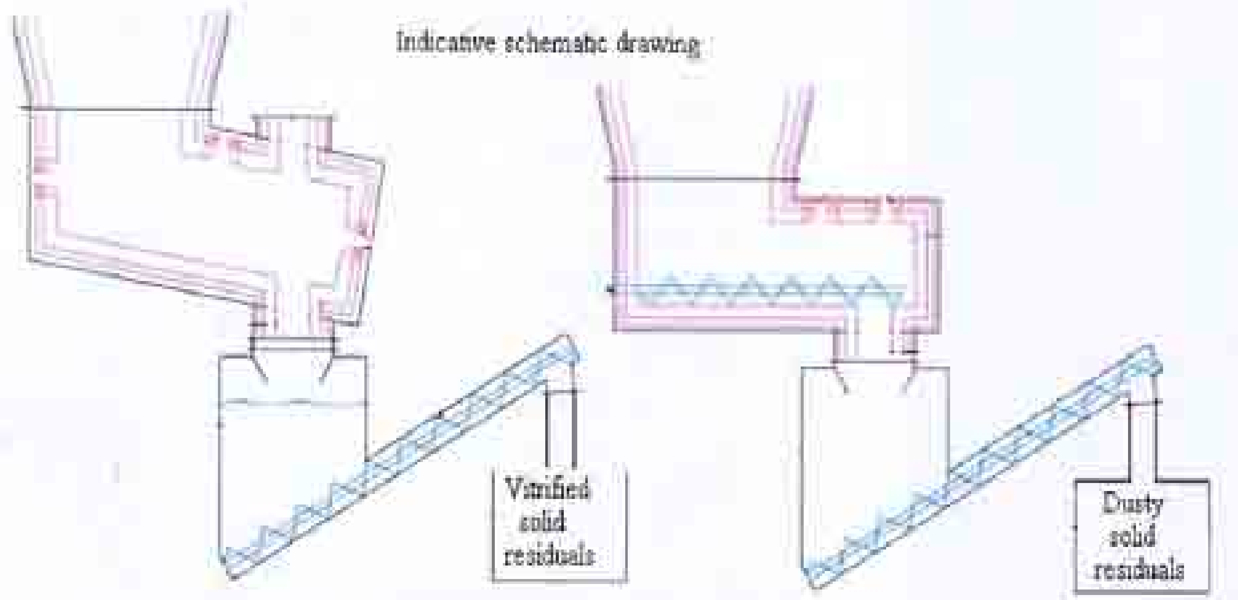


The thermal profile of the gasification reactor is reached and kept through the series of torches installed in the suitable section of the reactor. Each torch has electronic gauges and proportional control regulation valve for combustible and comburent gas.

The flow rate values of each gas are set in the plant control room; they will be automatically maintained. The fuel gas flow rate regulation of every torch is automatically determined by the temperature, which is sensed by the suitable thermoelement located close to the torch itself. In this way it is possible to set up the temperature value of the thermal profile established for that reactor or that specific application in the various areas of the reactor itself.

3 GASIFICATION SOLID RESIDUALS EVACUATION SYSTEM

The section of extraction of the gasification solid residuals, obtained in the lower part of the reactor, is foreseen with two working systems and consequently through two different solutions. Another characteristic of the WR system is the double possibility of extraction form of the solid residuals. It can be provided with this thanks to the variable thermal profile that allows to present these residuals, entering this section, at the most suitable temperature in function of the final treatment which they must undergo.



WR reactor : treatment alternative system and gasification residual evacuation

3.1 EXTRACTION OF DUSTY RESIDUALS

The first solution foresees the evacuation of the residuals in dusty solid form. This solution is adopted when, because of the typology and the homogeneity of the raw materials fed to the gasification reactor, it is possible to characterize the quality of the residual inorganic substances, so that they can be used in the same process which has produced them or as raw materials in other processes.

This section consists in a horizontal cylindrical chamber hooked under the gasification section, into which a screw is set . In this zone one or more torches are installed which are fed with comburent lightly in excess, allowing the possible residual carbon oxidation contained into the dusts. The exercise temperature in this section, is about 700-800°C and however it is determined by the fusion point of the residuals, that has never to be reached. The residual dusts, pushed by the screw, are discharged through an exit placed in the lower part at the bottom of the cylinder.

3.2. RESIDUALS EXTRACTION IN VITRIFIED FORM

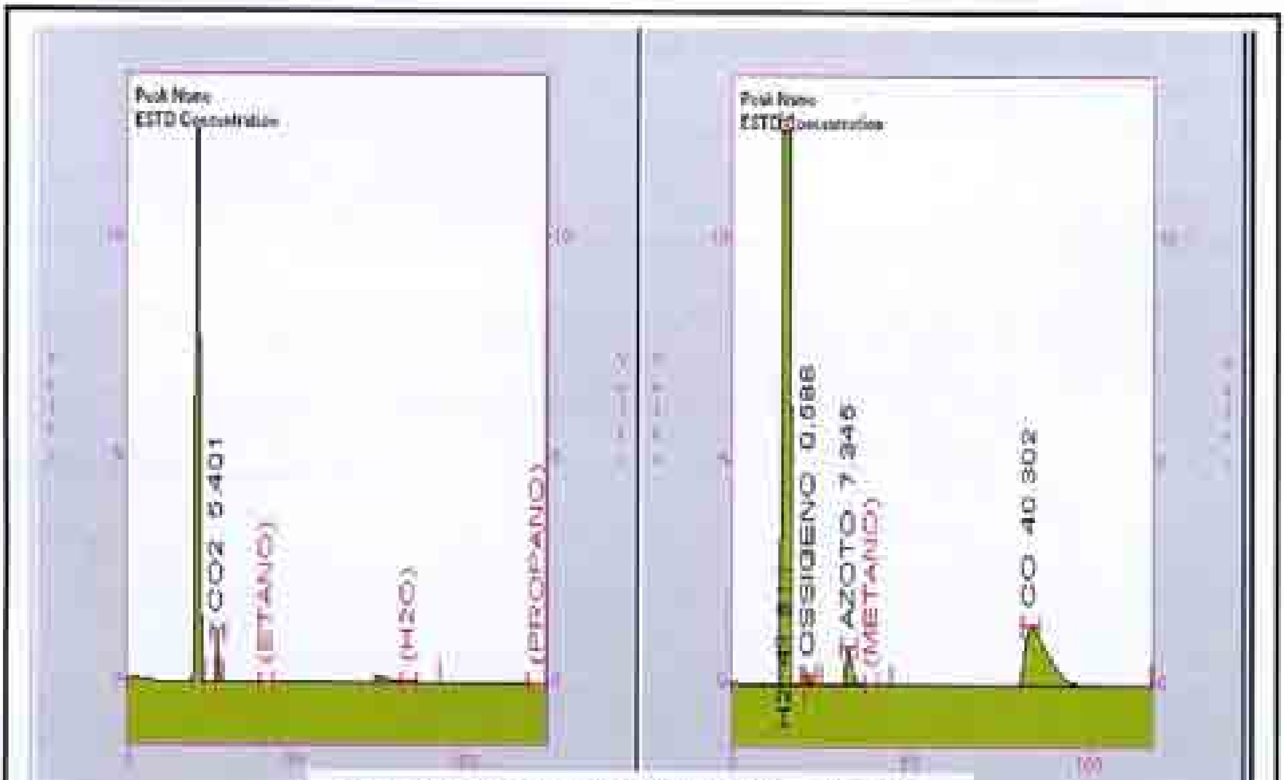
The second solution, concerning the system of evacuation of the solid gasifications, foresees the vitrification of the same ones. This solution is adopted in the cases in which, for the typology and the heterogeneity of the raw materials fed to the gasification reactor it is impossible to foresee the reuse of these solid residuals in other industrial processes, or due to the analytical characteristics these solid residuals can constitute an enviromental risk. In this case by taking the residuals to fusion, followed by the sharp cooling in water, the vitrification of same is obtained, by making them completely inert as the process turns out irreversible. This inertization process is obtained by the realization of a residuals evacuation section, hooked, through the connection area, under the gasification section.

The evacuation section consists of a parallelepiped chamber horizontally set with slope towards the discharge point placed in the lower side. The exercise temperature, determinated by the necessary overcoming of the point of fusion of the residuals is of 1500°C. This thermal regime is obtained through at least 2 or more torches fed with comburent dosed with a partial excess, according to the stoichiometry, to guarantee a lightly oxidizing atmosphere which allows the oxidation of the carbon eventually contained in the solid residuals.

Vitrified gasification residuals

4. WR: PRODUCTION OF HYDROGEN AND CO2 FROM SYNGAS

The WR process, the characteristics of the gasification reactor, the specific management and the process control, allow to obtain a syngas with concentration of hydrogen from ≅ 40% to ≅45%.The chromatographic in the figure here below highlights also the percentage concerning CO, CO_2, O_2, N_2.

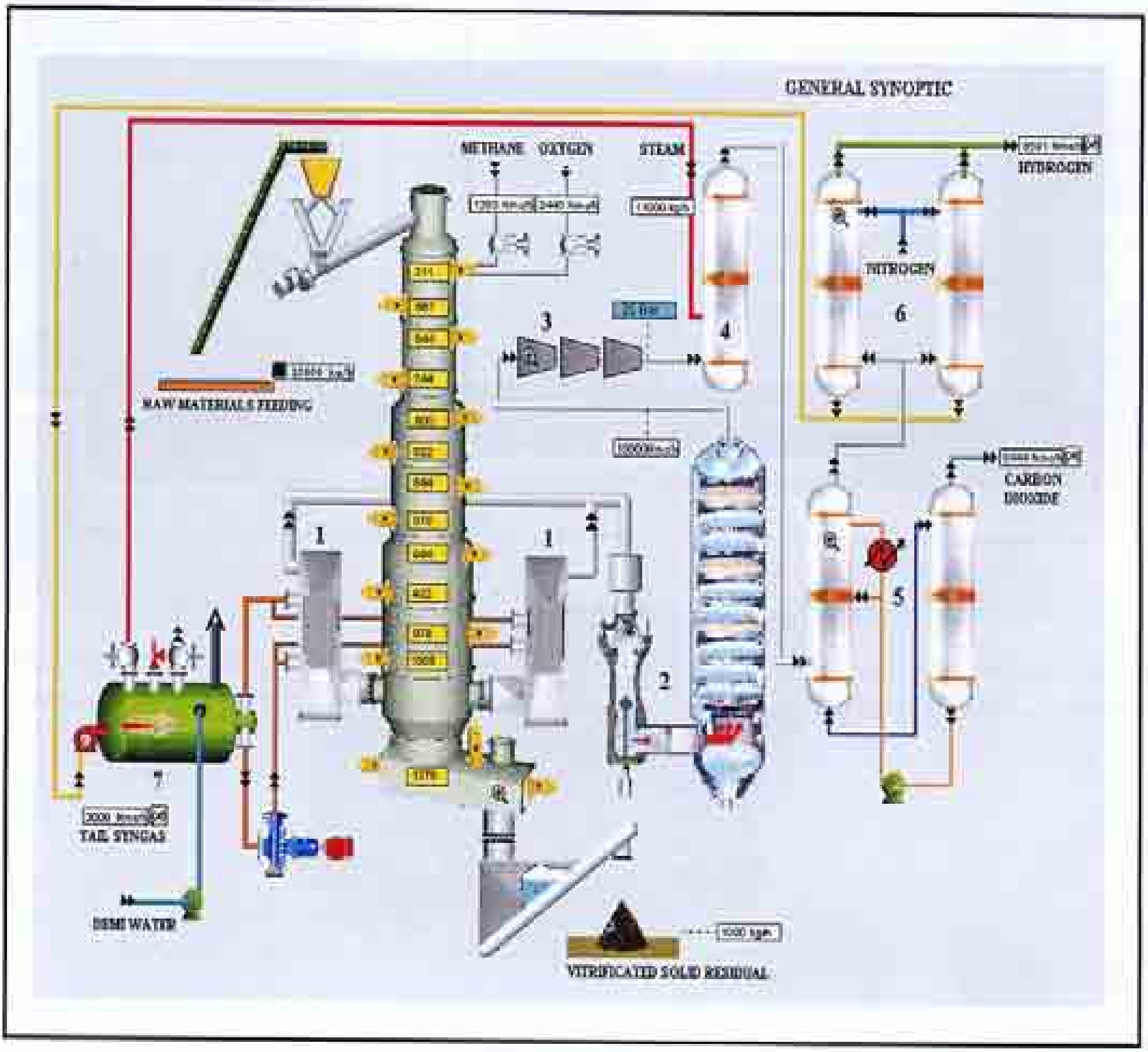


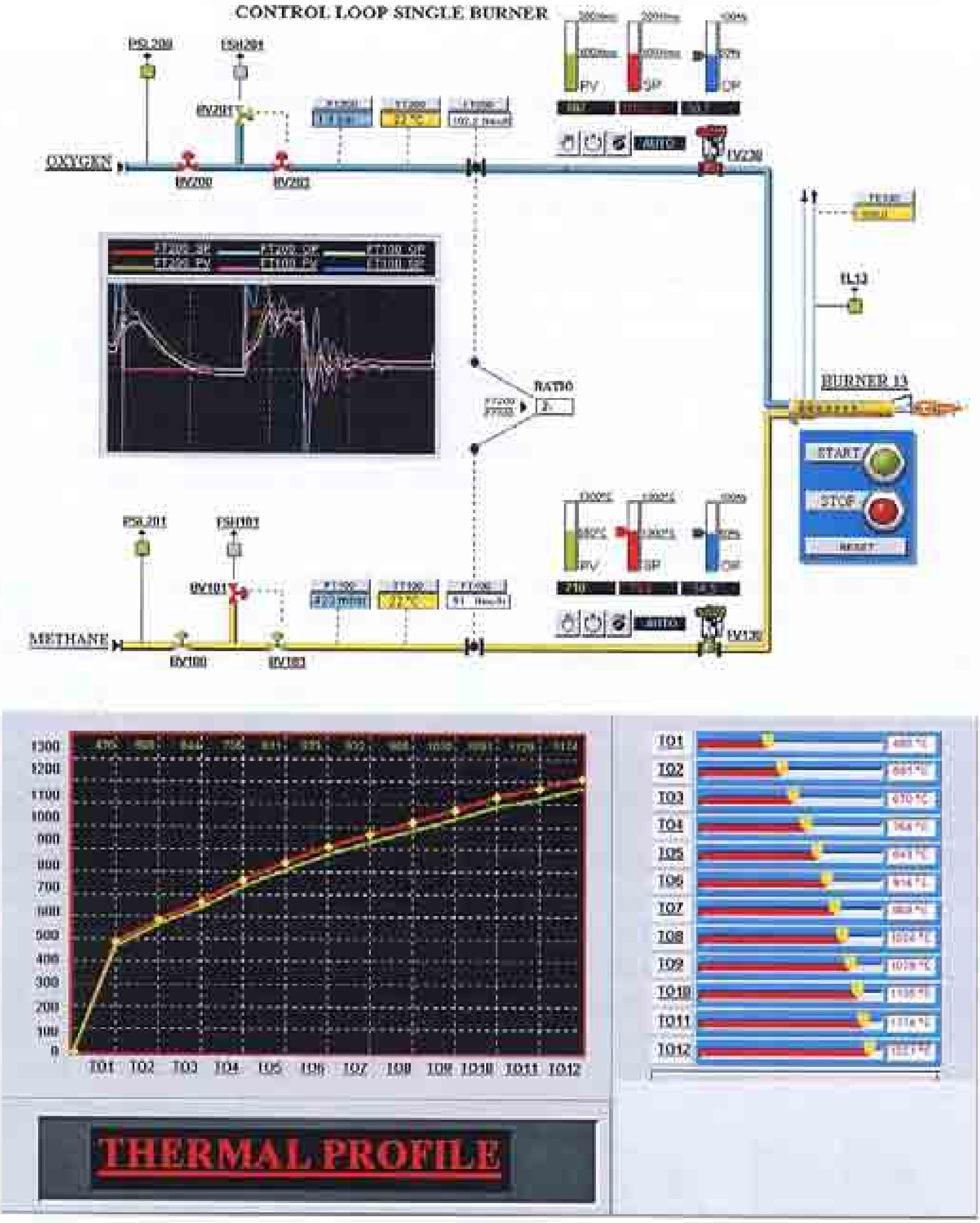
WR: SYNGAS GASCHROMATOGRAPHIC ANALYSIS

In this second plant part a series of treatments, aiming at the maximization of the hydrogen production, separating it from the substances and the impurity which compose the syngas, is made.

The technologies and the equipment included in the WR process to complete the plant, already widely tested in similar processes, are the following ones:

1 **Heat recuperator**
2 **Syngas neutralization and purification**
3 **Syngas compression unity**
4 **CO in H2 conversion reactor**
5 **CO2 recovery**
6 **H2 separation from the residual syngas**
7 **Steam production boiler**





Gasification Reactor : Thermal Profile Setting

OLIVIER

4.1 HEAT RECUPERATOR

The syngas produced in the gasification chamber comes out through flanged little sections set at 180° one from the other. Connected to each of these little sections two heat exchangers are installed to cool the syngas from ≅1200°C to ≅ 250°C, recovering the heat for the production of steam. The heat exchange takes place between the syngas, flowing inside the pipes, and the diathermic oil which comes outside the pipes. The diathermic oil is made circulate, in a closed circuit connected to a steam generator, where the enthalpy contained in the syngas is recovered. The produced steam is used in the reaction of conversion of the CO in H2+CO2.

4.2 SYNGAS NEUTRALIZATION AND PURIFICATION

The neutralization and purification of the syngas is made in a high performance multistage system so that the outgoing syngas does not present incompatibility characteristics with the following reaction phases. The syngas can eventually, contain principally, carbonblack, metals, acid substances according to the typology of the fed raw materials. The multistage system foresees some specific intervention sections for every present pollutant typology. For this reason every treatment section is provided with a suitable circuit, for the absorption of one specific pollutant or a specific pollutant family, which allows the separation and the possible recovery of the absorbed substance.

The first unity is constituted by a quencher for the cooling and the saturation in water of the syngas. The temperature of the syngas is taken from ≅250°C to ≅90°C and the saturation in water allows a better efficiency in the following treatment phase.

The second unity is constituted by a variable throat Venturi. The "must have" characteristic of this section of plant is the high efficiency of separation of the carbonblack, (disguised as micronic dusts) possibly contained in the syngas. The throat of the Venturi is an adjustable type. The central bob, it is equipped with, can vertically move in order to change the passage area through the throat. In such a way the gas ideal speed can be kept, through the throat, within a very wide gaseous flow rate range, always remaining in the optimum of pressure drop and equipment efficiency. The liquid process, kept in recycle by a suitable pump, is continuously filtered to separate the particles being in it. These particles, essentially constituted by coal dust, are refeded to the gasificator.

The third unity is constituted by a multistage scrubber. This equipment is constituted by a column inside which three hydraulically separated zones exist at least. In the first one, destined to the absorption of the neo metals possibly contained into the syngas, a series of trays is inserted, suitable to the purpose, on which, the absorbing solution kept to ph acid is made circulate by a suitable pump. The circuit of this solution is equipped with a suitable treatment section where the metals contained in it are made filter and separate, and the solution is put again in cycle precipitate.
In the second zone, destined to the neutralization of the acid substances, another series of trays suitable to the purpose is inserted, on which it is made circulate the neutralizing solution kept at basic ph by suitable pumps. The circuit of this solution is equipped with a suitable treatment section where the obtained, filtered and separated salts are made precipitate, and the solution put in cycle again. The third zone is composed of a high efficiency demister for the separation of the micro drops dragged through the purified syngas. No discharge of liquid substances is foreseen from the syngas purification plant.

4.3 SYNGAS COMPRESSION UNITS

The purified and neutralized syngas is sucked by a multistage compression unit which has the task to overcome the pressure drops, produced by the equipment placed on the top, and compress, the same syngas, to the pressure of 25 bar, necessary to the following reaction phases.
The exercise pressure difference between the equipment at the top and the equipment at the bottom being high, it is necessary to use a compressor using a compressor with at least three compression phases in series to reach the established working pressure. The compressor is equipped with a flow rate regulation system connected to an electronic pressure transmitter, positioned on the gasification chamber.

4.4 CO IN H2 CONVERSION REACTOR

In this reactor the syngas stream and steam are fed at the pressure of 25 bar at the temperature of 280 ° C. Due to these conditions, in the presence of the catalyst, the $CO+H_2O \leftrightarrow CO_2+H_2$ conversion reaction takes place with a conversion performance equal to 84%. The reaction is exothermic and the produced heat is recovered, through a heat exchanger using, the gaseous stream coming out from the reactor to heat the stream entering the conversion reactor.

4.5 CO2 RECOVERY

This section is composed of a couple of columns, destined to the separation of the CO_2 contained into the fed syngas. In the columns a solution circulates, having 30% potassium carbonate in water, at the temperature of 80°C, and in order to increase the absorption speed, suitable activators are used.

In this condition, in the first column kept at a pressure of 22 bar, the (exothermic) reaction $K_2CO_3+H_2O+CO_2 \leftrightarrow 2KHCO_3$ takes place. At this tower exit the syngas mixture contains about 2% CO_2 residual. In the second tower the desorption of CO_2 from the potassium carbonate solution is made by simple expansion and in steam stream stripping of the water solution which is so reproduced and sent again to the first tower. The produced CO_2 at 99.5% purity is cryogenetically cooled and liquefied and then sent to the suitable storage container and to the final use.

4.6 SEPARATION OF HYDROGEN FROM THE SYNGAS

The third section is composed of two columns destined to the separation of the hydrogen, (with purity of 99.9%), contained in the fed syngas.

The columns work at 21 bar pressure, and at 40°C temperature, and they are filled with molecular sieves. To have a continuous hydrogen production, the two columns must work in an alternated way.

The syngas is fed in the first column, where the molecular sieves keep the various present gaseous components, letting only the hydrogen pass, which is sent to the storage tank. When the molecular sieves reach the saturation, the first column is closed and the syngas is fed in the second column, while the first is put in regeneration with a nitrogen stream and it is prepared for the following cycle. The recovered hydrogen separation performance, in comparison with the fed one is equal to 81%.

The tail gases of this section, obtained in the regeneration phase with nitrogen and composed of H_2, CO_2, CO, N_2, are given back at a pressure of 1.5 bar and used as fuel gas in the boiler for the steam.

4.7 STEAM PRODUCTION BOILER

The boiler for the steam production foreseen for this application uses a double energy source. The first consists of the heat recovered by the exchangers installed for the cooling of the syngas going out from the gasification section. The second source consists of the enthalpy contained in the tail gases ($\cong$ 2000 Kcal/Nm3), which is used as fuel in the burner of the boiler itself.

5. WR: THE ECOLOGICAL ASPECT

Waste Remedy must be analysed, evaluated and judged, above all as regards the ECOLOGICAL APPEARANCE. In fact every other evaluation must be considered as secondary, even if the right importance is given at each.
If WR wants to be "the solution" of the problem, ecological-environmental type direct consequences must not and can't be tolerated.
This concept is better clarified by analysing the most important aspects of the subject at issue.

- RAW MATERIALS IN FEEDING

The WR process, whose aim is to produce, needs the fed raw materials to correspond to determinate characteristics, (for instance Refuse Derivate Fuel of Municipal Solid Wastes) with qualitative ratio, which are well-known in the vastness of the admitted typologies. This means that the careful selection of the treated wastes becomes compulsory. This selection takes to the recovery of all those substances which can have a direct value of market, or other arrangements, forming the most suitable composition of the raw materials in feeding. It must be remembered that the gasification reactor is not equipped with a "big door" where everything can be introduced in an indiscriminate way just because it must be burnt, and the remedy to the consequences of this action is in other parts of the plant. This characteristic could seem a limitation, but analysing all the aspects of the problem it is clear that this constitutes the correctness of the approach and **the guarantee** for the achievement of the result.

- THE GASIFICATION

The gasification is the only process, **without emissions**, which allows "to burn" the wastes, using them as raw materials.
The WR process, realizing the fast gasification with variable thermal profile, optimizes the gasification, allowing the hydrogen production and the recovery of the carbon dioxide by the syngas produced.

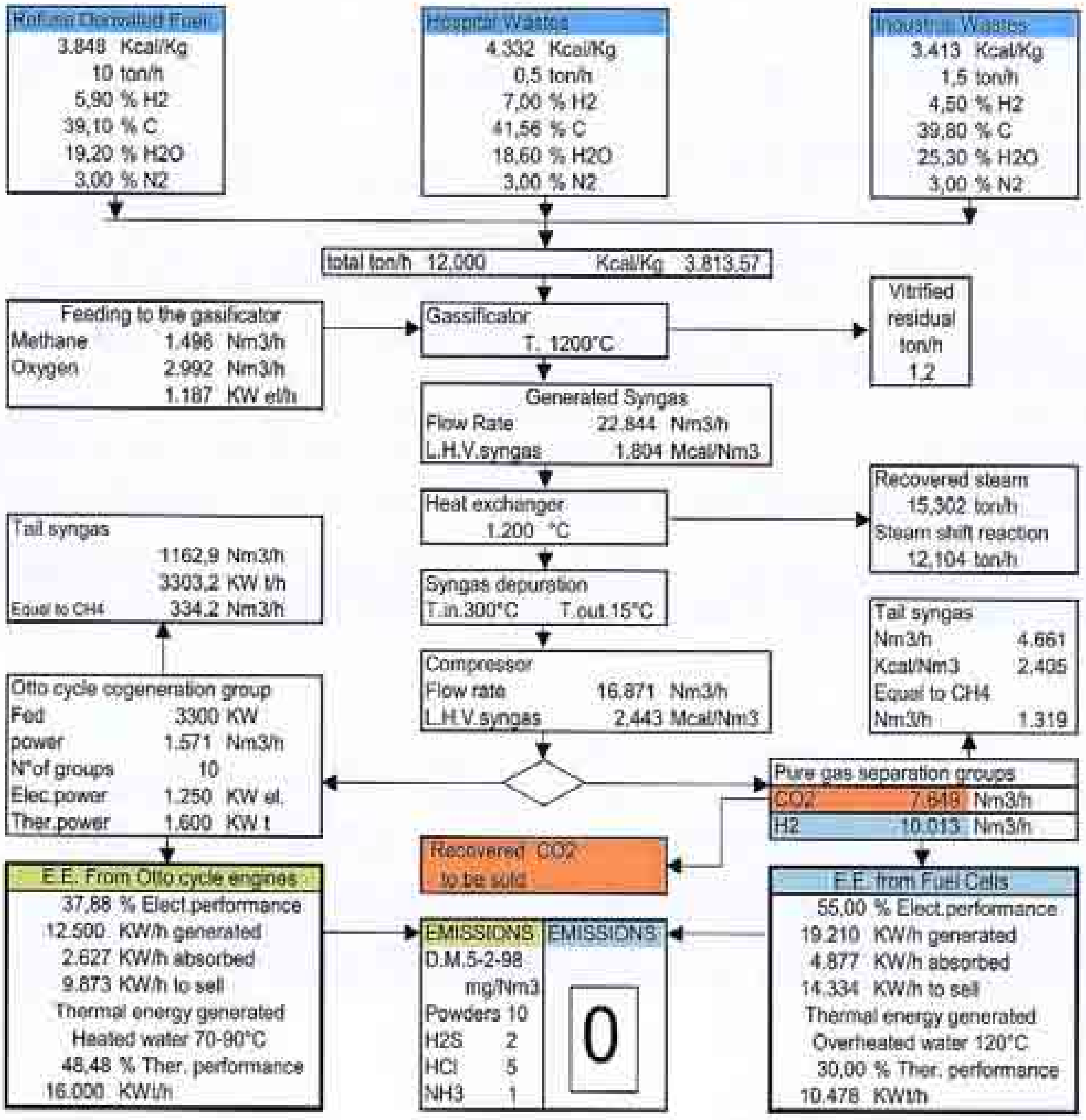
- GASIFICATION RESIDUALS VITRIFICATION

The solid gasification residuals coming from the WR process are vitrified. This guarantees the total inertia towards the environment and allows also the reuse, if possible, in other utilization (such as road foundations, pre-shaped blocks etc.).
In the case of homogeneous raw materials feeding and consequently to the obtaining of residuals from the well-known composition, it is possible not to proceed to the vitrification just limiting to the thermo-oxidation by unloading the dusty form residuals and allowing their reuse in other processes.

6. WR: THE ENERGETIC ASPECT

The generation of energy by renewable sources is one of the fundamental concepts of the WR process. The production of H2 and CO2 at high purity degree, needs a series of processes and reactions led with the aim to obtain the highest possible performance. For these reasons also for the electric energy generetion systems technologies, guaranteeing the highest performance, have been adopted.

In particular the use of the hydrogen in the fuel cell constitutes the solution par excellence as, besides guaranteeing very high electric performances, it allows to keep the **emissions equal to zero.** In the flow chart, here below, the various energy performances are shown according to a feeding hypothesis.



7. WR: THE SAFETY ASPECT

The typology of the reactions carried out, the produced gas (hydrogen), impose a due attention with respect to the way of realization of the plant and to the management of the process. The design of the plant adopts all the precautions normally used in the chemical or petrochemical plants, because some sections of the plant are alike.
Particular attention is paid to the active security that is principally realized with the following solutions.

- **Modular reactor**
  The dimension of the gasification reactor is intentionally limited to contain the volumes of the flammable gases. For this reason the maximum capability range of every gasificator is fixed from 8 to 10 Ton/h. The installation of several gasification modules always allows to reach the wished project flow rate.

- **Fast gasification**
  The adoption of the WR process allows the realization of the fast gasification. This means that inside the reactor, there is no accumulation of substances to be gasifed and the reaction inertias are very low, allowing the stop of the production of flammable gases in a very short time.

- **Computerized management**
  The management of the whole plant is totally computerized. A complete series of analysis and control instrumentation, in a few cases installed in double, connected to a powerful elaboration and calculation system, allows the management in real time of all the process variables and consequently the optimum regulation of the reaction parameters. The whole equipment is equipped with its diagnostic which allows to point any malfunction of each instrument or plant part.

- **Adequate plant engineering**
  A suitable plant lay-out study, the observance of the distances of security among the various equipment, the reliable instrumentation adoption, the operaction logic sequence, the intrinsic security electric plants, the quality of the used materials, constitute an indicative and not exhaustive list of the choices also aiming at the safety of the plant.

8. WR: THE NORMATIVE ASPECT

This paragraph is worth only for the plants installed in Italy.
The WR process, using the technology of the gasification, falls down under the ministerial decree normative aspect listed below.
The law 59/97 and the regulation of simplification of the decree 112/98, foresees a single proceeding for the settlement of productive activities by a unique municipal area, with wide self-certification and recourse faculty to the conference of the services.

Ministerial decree February 5th, 1998

Identification of the not dangerous wastes exposed to the simplified recovery procedures according to the articles 31 and 33 of the no.22 legislative decree February 5th, 1997

- Typology: Derived gases (190199)

1.1.1. Origin: pyrolysis and/or wastes gasification plants, as at point 17 of enclosure 1
1.1.2. Characteristics of the gas:

gas deriving from pyrolysis and/or gasification processes having the following characteristics:

L.H.V.	min.	4,500	kJ/Nm^3	dry gas
H2S		2	mg/Nm^3	"
Powders		10	mg/Nm^3	"
HCl		5	mg/Nm^3	"
NH3		1	mg/Nm^3	"

1.1.3. activity and recovery methods of:
the use of derived gases is allowed in plants having nominal thermal power energetic conversion higher than 6 MW, being also supplemented with the gas production system, production of the gas, with the characteristics listed below:

b) to fixed internal combustion engines are applied the following limit emission values reported to an oxygen content in the anhydrous smokes equal to 5% in volume:

Dusts	(hourly average)	10 mg/Nm3
Carbon monoxide	(daily average)	300 mg/Nm3
HCl	(hourly average)	10 mg/Nm3
HF	"	2 mg/Nm3
Cd+Tl	"	0,05mg/Nm3
Hg	"	0,05mg/Nm3
Sb+As+Pb+Cr+Cu+Mn+Ni+V+Sn	"	0,5 mg/Nm3
Nitrogen oxides	"	450 mg/Nm3
Total organic carbon	"	150 mg/Nm3
PCDD+PDC (as equivalent dioxin) (as medium value noticed for a sampling period of 8 hours)		0,1 mg/Nm3
Aromatic polycyclic hydrocarbons (as middle value noticed for a sampling period of 8 hours)		0,01mg/Nm3

For the other pollutants the fixed limit emission values are applied according to article 3, paragraph 2, of the decree of the President of the Republic no. 203 of 1988 for the corresponding typologies of plants.
In plants beyond 6 MWt the control in continuous of carbon monoxide and nitrogen oxides must be made.

9. WR: THE ECONOMIC ASPECT

"A strong sustainable development is able to promote also the necessary changes in the economy. The aims and the priorities of these changes are clear and identified. ***The enviromental goods are worth to be included in a real and complete evaluation of costs and benefits.***

The market must conform to the enviromental aims actually to become a really efficient tool of allocation of the resources.

In the relationship between international commerce and environment, the priority is the sustainability, not the liberalization. When the liberalization, avoiding protectionisms damaging the environment, is useful to the sustainability, it must be promoted; when on the contrary it brings to the unsustainable exploitation it must be limited.

When the market economy obstructs the start of new sustainable technologies, defending consolidated and unsustainable technologies, it must be regulated with laws and oriented with economic and fiscal incentives."[2]

♣

The WR process, under the economic aspect must be analysed according to the double use of the produced syngas.

Through the direct use of the syngas in the Otto cycle engines, ensuring a drastically lower environmental impact and a higher energy performance than the traditional technologies of wastes disposal, the value of the investment and its amortization are perfectly comparable to the best alternative technologies.

Cogeneration groups – Otto cycle engines

[2] From : *Uno sviluppo capace di futuro*, Edo Ronchi, Il Mulino

EXISTING PLANT IN WORK

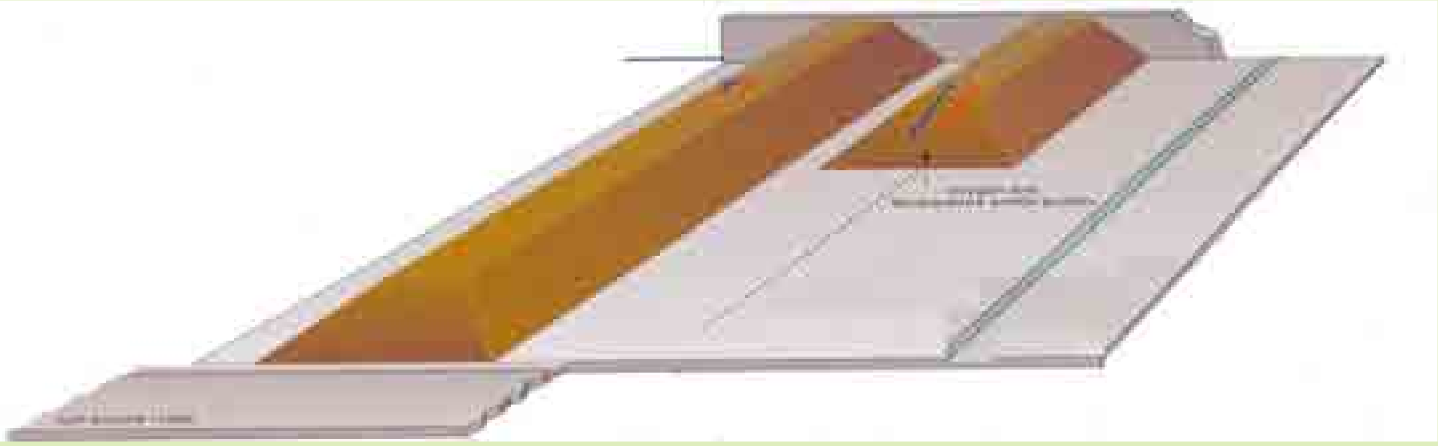
OLIVIER

11. WR: THE EXPERIENCES

The WR process is based on a series of technologies which have already been widely tested in the chemical and petrochemical industry. In fact, the gasification, the syngas neutralization , the $CO+H_2O \rightarrow H_2+CO_2$ reaction conversion, the recovery of the CO_2, the H_2 separation with molecular sieves, are all reactions having development mode without uncertainties and having certain performances. The news of the WR process is constituted by the assembly of these technologies and by the constructive and functional characteristics of the gasification reactor applied to the "disposal" of the wastes, which come from a recently deposited patent request.

The great number of experiences acquired in plants with the the same characteristics and problems concerning the WR process, allowed the planners, starting from these already tested industrial plants, the dimensioning and complete design realization of plants according to the WR process.

OLIVIER



Turn over machine for compost

Model

JENZ UM 5000

with engine Mercedes-Benz OM 336LA
Power 147kw (200hp)
Treated material size 5,50 x 2,20 m
Air conditioned cabin
Chain traction

OLIVIER

OLIVIER

OLIVIER

OLIVIER S.R.L.

OLIVIER CHILE
Reg. Office Chile:
896 Laguna Verde
1890 Santiago

US-Contact Office:
10 S. 3rd. St. Suite 300
San Jose, CA 95113
Fon: +52(1322) 150 2205
Fon: +1(408) 472 4285
Fax: +1(408) 877 1528

OLIVIER S.R.L.

OLIVIER MEXICO
Head-Office Mexico:
Av. Santa Fe 495, Floor 4
Col Cruz Manca, Cuajimalpa
Mexico D.F., C.P. 05349
US-Contact Office:
10 S. 3rd. St. Suite 300
San Jose, CA 95113
Fon: +52(55) 3300 5540
Fax: +52(55) 3300 5510
Fon: +1(408) 472 4285
Fax: +1(408) 877 1528

OLIVIER UPC

OLIVIER NIGERIA
Reg. Office Nigeria:
#8 Akinsemoyin
Surulere, Lagos

US-Contact Office:
171 17th street NW
Atlanta, GA 30363
Fon: +1(404) 625 9882
Fon: +1(404) 862 0580
Fax: +1(404) 873 7025

OLIVIER LTD.

OLIVIER SAUDI ARABIA
Reg. Office Saudi Arabia:
King Fahad Road 1
P.O. Box: 295551
Riyadh 11351
Fon: +966(1) 4193909
Fax: +966(1) 4193782
Mob.: +49(170) 9179979

www.olivier-group.com

OLIVIER AG

OLIVIER GROUP
Head-Office Suisse:
Untermüli 6
6300 Zug
HQ@olivier-group.com
Sales-Representative:
Mob.: +49(177) 838 5814

OLIVIER EUROPE
Administration-Office:
Lindenstrasse 16 b
88453 Erolzheim
Fon: +49(7354) 930 110
Fax: +49(7354) 930 150
Mob.: +49(173) 670 3970

OLIVIER MIDDLE-EAST
Sales-Representative:
P.O. BOX 97800
Sharjah, U.A.E.
Fon: +971(6) 5562336
Fax: +971(6) 5734788
Mob.: +971(50) 4256888

OLIVIER GROUP is the exclusive dealer for

ATS GROUP

The manufactorer is continously improving on the design of its products.
The pictures and descriptions in the booklet may not reflect the latest design improvements made on this product.
OLIVIER GROUP is the exclusive dealer for ATS GROUP in Chile, Mexico, Nigeria and Saudi Arabia. Our headquarters are in Switzerland.