Chapter 14

The Plant of the Future

Developed countries must owe their prosperity to the Industrial Revolution, to the machinery that the "capitalist" companies have been keen to create.

Currently, worried about their standard of living, developed countries look for ways to respond to the challenges posed by the depletion of fossil resources, water stress, climate problems like global warming, problems related to the environment, energy, globalization, increasing world population, the enormous disparities between rich and poor countries and the de-industrialization of developed countries.

De-industrialization, synonymous with unemployment, is consistent with the invasion of the products *made in China* and other emerging countries, and the relocation of the means of production from the developed countries toward countries with cheap labor.

The emerging countries, driven by growth dynamics, do not have the same questions as that of the developed countries; as for the poor countries, they try to survive in its *strictest sense*.

These problems, already mentioned in this book, are closely related to *consumption* and to industry which serves it by using multiple technologies; some rich countries have to start questioning them.

Chapter by Jean-Pierre DAL PONT.

This is currently the case with the nuclear industry after the Fukushima (Japan) disaster in March 2011. Countries like Germany, hardly 3 months after this disaster, banished the nuclear industry from the horizon for a few decades.

NOTE.– In France, 75% of electricity comes from nuclear sources as opposed to 20% in Germany.

This single example is enough to pose the crucial problem of interface between the company and its production facilities and the technological choices that give rise to fear and distrust such as GMOs, nanoparticles or genetic engineering.

14.1. Developed countries – companies – industrial firms

Interviewed by the *Straits Times*, a newspaper in Singapore, Lee Kuan Yee, founder of this city-state with about 5 million people, defined a developed country as a country made up of interacting systems. Educational, banking, industrial, health, civil protection, defense, transport, and food systems, a system related to everyday life, welfare, recreation, and so on.

The need for *governance* of such systems, as well as their *vulnerability* is obvious.

14.1.1. *France – heat wave of 2003*

In August 2003, a heat wave aggravated by peaks of nitrogen oxide and ozone, due to the lack of wind, led to excess mortality, estimated at about 15,000 people particularly among the elderly. The mortuary rooms were saturated, a cold room from the Rungis international market and refrigerated trucks were requisitioned.

A political crisis followed! It is surprising that a country as organized as France could be the location of such events: the lack of coordination between different administrative bodies and the lack of governance was incredulous.

The power outage of New York in August 2003, the devastating effects of hurricane Katrina in New Orleans in August 2005 that raised questions about the design of levees of the Mississippi; and the catastrophe of Fukushima reflect the vulnerability of our *complex* societies.

Jacques Repussard, director of the IRSN (the French Institute for Radiological Protection and Nuclear Safety) [REP 04] analyzes the perception of the French regarding the industrial risk that they believe is primarily related to chemical risks, nuclear risks, waste management, air pollution, and so on.

The French worry about “the increasing dependence of our society toward the more and more inevitable technologies and networks that they generate (energy, transportation, telecommunications, hospital facilities, etc.)”.

Peter Senge [SEN 08] states that we are entering the ground floor in the post Industrial era. He observes that all the ages have an end “*from the Iron Age to the Bronze Age, from the age of the Renaissance to the Reformation ....*”. “*The Industrial Age which has shaped our life styles and our world view for generations, is no different*”.

It highlights American consumerism, 5% of the world’s population consumes almost half of the drugs and 25% of the fossil fuels … “America is addicted to oil”, stated president G. Bush.

The companies, from the Industrial Revolution, that has shaped and maintained them, are central to the debate as creators of wealth and their impact on society. We have already highlighted this.

The concept of sustainable development that emerged in the 1960s has slowly but surely impacted on the industrial companies. In a kind of irony, the industrial disasters (Seveso, Bhopal, etc.) and environmental disasters (uncontrolled and excessive use of pesticides including DDT, etc.) have precipitated this movement [SEN 08].

The discovery of the chemistry of the atmosphere by Kreutzen *et al*. and the ozone hole created by fluorinated compounds, the impact of GHG (greenhouse gases) on the climate have evoked an international awareness that is about to disrupt the corporations, questioning its goals.

The book by Elisabeth Laville [LAV 06], *L'entreprise verte*, has the subtitle “sustainable development changes the company to change the world”. In France, an eponymous ministry came into being. The major companies are rated on these aspects by Vigeo, founded by a renowned former French trade unionist.

E-commerce is growing at a rapid pace and fairtrade is also moving with it at a brisk pace. The citizen wants to know if his T-shirt was made by children or by *slave workers*, how much was paid to the distant producer for coffee and whether the benefits are equitably distributed among the players of the chain, which ranges from plantation to distribution.

Therefore, the company is forced to review its products and the services which are its goals! It is also equally constrained by more and more stringent regulations, such as REACH in Europe.

14.1.2. The *ISO 26 000 standard*

This was the first international standard on the social responsibility of organizations published on November 1st 2010.

It is based on the three pillars of sustainable development: economic, environmental, and social. It is a standard of governance whose objective is to clarify the responsibility of the company, facilitate dialog with its *stakeholders*; in the broadest sense, it takes into account human rights and the impact of the company on the environment.

The developed countries are left with the *ease of importation*: the need to produce no longer appeared to be necessary ... nor rewarding! Marketing and finance have found favor with the new graduates who neglect the production system.

Some significant countries advocated a *service* society! Even though services cannot bring their added value only to what has been produced!

Wealth is created by *manufacturing*, a term which appears to be more driving than production.

The profit of the company, its wealth, begins at the plant!

For having forgotten it, the United States, which brought the Industrial Revolution to its pinnacle, sank into an unprecedented deficit.

From the early 1980s, Hayes and Wheelwright [HAY 84] have sounded the alarm! They described back then the *vulnerability* that U.S. companies face with their competitors, mainly Japanese competitors. These authors developed the concept of *manufacturing strategy*, which we have dealt with in this book and which we can summarize by the need to maintain *cohesion* between the needs of the market in a long-term vision and the production facilities.

Manufacturing has become a *competitive weapon*.

The same authors later joined Kim B. Clark [HAY 88] and resumed developing the same ideas 4 years later, observing that the United States were declining more and more, while the whole world had admired their incredible industrial epic during World War II. At that time, factories were converted in record time to make planes, tanks, means of maritime and land transport, not to mention the Manhattan Project for the construction of two atomic bombs.

The *Liberty Ship*, by itself, symbolizes the power and quality of the American war industry; it implemented new manufacturing methods, it used standardization, methods of continuous improvement that reduced of the duration of construction from 250 days to 50 days. Innovative training methods educated those who worked on them.

Rosy the riveter is a popular icon that symbolizes the 6 million women who participated in the war effort: among them was a certain Norma Jean Mortenson, who is better known by the name Marilyn Monroe.

To understand the production system, we have to first try to define it.

14.2. Typology of means of production

The typology of means of production is a complex subject, given the extraordinary diversity of technologies used and the products derived from it, the amount of their investment, their location, staff who implement them and how they do it.

The manufacture of an Airbus A380, of 1,000 tonnes/day of ethylene, a drug whose synthesis involves a dozen steps, and the assembly of cars in series, involves completely different concepts. What about an oil platform in the North Sea or a paper pulp plant on a barge in the jungles of Borneo?

Joan Woodward (1916–1971), an English sociologist, laid the foundation for a classification in the 1960s [DAL 07a, HAY 84]; since then, manufacturing systems analyses have been developed [CHA 90].

The approaches are different, sometimes contradictory; the words do not always have the same meanings, especially when there is a translation. It is important to emphasize at the outset that *the organization of work*, *management of the production facility and the concept of manufacturing are closely linked*: one does not go without the other [DEC 80].

We will use the classification of Hayes and Wheelwright [HAY 84] by simplifying it. The authors distinguish the following production methods: project-based, job shop, assembly line, and continuous production.

– The *project* generally refers to a single object, usually a prototype. This is the case of civil works (dam, airport), very large pieces of equipment (ship, power press), or even a new plant. The project is assigned to a project team that executes and enforces a number of tasks according to a predetermined plan. The organization of work uses PERT or other software packages (we have discussed this in Chapter 9).

– The *job shop* where single parts are produced usually in small batches, for example, a set of machine tools, a printing plant are typical of this type of industrial organization. The part to be manufactured can move from machine to machine. Some machines can be grouped into specialized cells to perform a number of additional tasks.

– In some types of job shops, the *batch* undergoes several transformations, by passing successively from process unit to process unit. This is the case of fine chemicals plants where a raw material will react with other raw materials in successive reactors: for example, the oxidation process unit is followed by nitration, which is followed by hydrogenation in specific process unit.

– *The process unit* consisting of successive online work centers.

The final object is to be assembled by the supply of components at each stage. It moves from station to station at a determined speed. This is the invention of Ford in the automobile industry at the beginning of the last century.

– *Continuous process units*, this is typically the petroleum industry, heavy chemical industry. The continuous process unit differs from the assembly line by the fact that the product to be transformed is "continuous" and not "discrete" (we speak of 51.8 tons of kerosene but not about 51.8 cars!).

NOTES.– Some authors refer to the *production process* as continuous process units. In fact, this designation only applies to the process units of physical or chemical transformation of matter which, of course, is often implemented in the continuous process units!

Others call *mass production*, the production of large volumes of "discrete" objects in very short cycles, such as the manufacture of screws or plastic objects coming from injection molding machines.

Others still fail to distinguish between the continuous flow process manufacturing and the industrial *fabrications* or "discrete" manufacturing that produces individualized objects.

VAT analysis

Another classification is based on the analysis of the flow of raw materials and semi-finished products up to their final stage of finished products (Figure 14.1) [CHA 90].

We distinguish the basic models and V, A and T. While keeping the same term, we have added the model I:

– *model I or a single line*, for example an installation line of single electrical appliances (a case receives different components during the passage of assembly through stations in series);

– *model V or divergent model*, for example a steel mill (the steel is processed into beams, rounds, wires, steel reinforcing bars);

– in the process industries, a basic raw material results in a product tree; currently, this is the case of bio-refineries, where plant starch leads to a multitude of byproducts;

– *model A or convergent model*, such as a mounting of an aircraft in an assembly hall;

– *model T (convergent/divergent)*: a basic product manufactured according to model A is the source of byproducts; for example, a model of a basic car is differentiated by its accessories or the color of its body.

In chemistry, *master batches* are sent to various places, to undergo local transformations; various ingredients, such as perfumes or dyes, may be added to detergents.

We can deal with a combination of these basic models very easily.

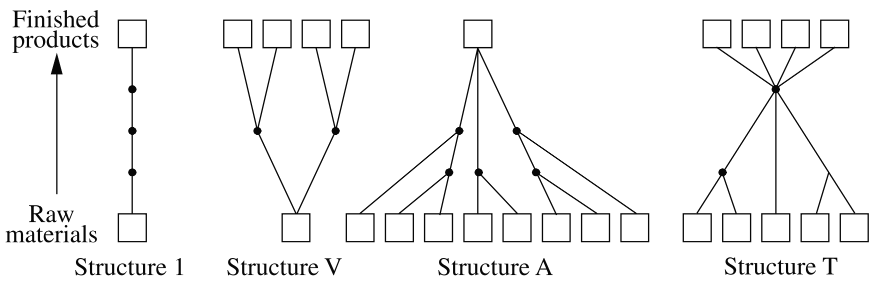

Figure 14.1. *VAT analysis [DAL 07a]*

14.2.1. *Industrial facilities reviewed in the light of the supply chain – flows*

The company is the seat of four major flows, symbolized in Figure 14.2:

– material flow (raw materials, work in progress, finished products, waste);

– financial flow (purchases, sales, production cost, etc.);

– information flow (customers, suppliers, production facilities);

– human flow (management of human resources).

The flow of energy does not usually appear in this classification because until now, in developed countries, energy was taken for granted. Will it be there in the future? The flows of energy can be negligible in fine chemicals, and dominant in heavy chemicals.

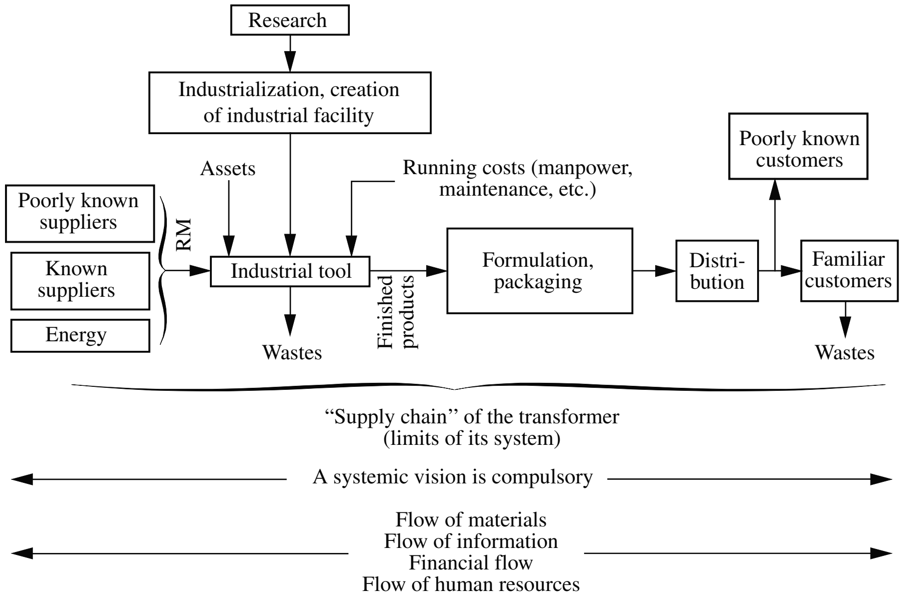

Figure 14.2. *Flows related to production*

This concept of flow appeared about 15 years ago [CHR 92, DAL 07], it is the basis of the concept of the supply chain (Figure 14.3), which sheds new light on the whole set involving transportation, purchase, management of manufacturing tools, management of raw materials stock, finished goods, work in progress inventories and distribution. This is a strategic vision that places the customer at the heart of the productive system.

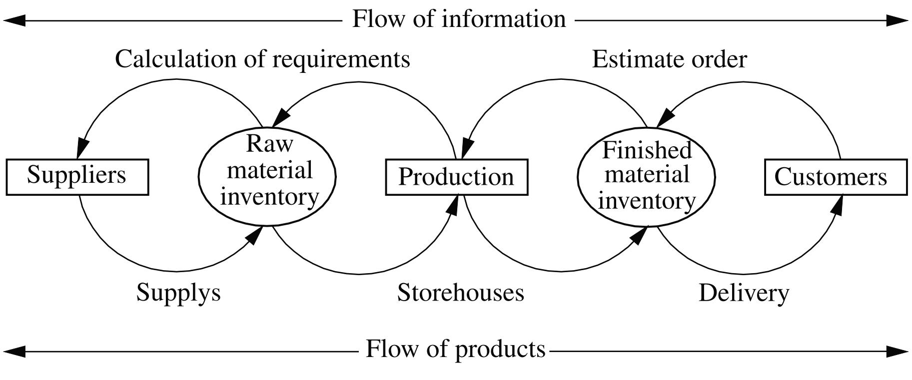

Figure 14.3. *Visualization of the concept of supply chain*

The purchasing function, distribution, and stock management are the key links of the *supply chain*: these are all processes that need to connect with the production itself:

– conditioning and packaging must be part of the design process, the presentation of the product may have an essential business impact (e.g. bottling of perfumes);

– the handling takes on very different methods that concern pallets, industrial trucks, conveyor belts, loading cranes, and so on;

– storage and transport also involve a variety of techniques that are sometimes very complex; a cold chain, the bulk handling of powders, air or maritime transport, to name but a few.

In some companies, the management of physical flows calls for ERP *(Enterprise Resource Planning)*; the stock situation and customer orders managed in real time thus make it possible to optimize the management of production facilities and reduce working capital needs. The company can have a global vision of its activities, improve procurement planning and product traceability, and optimize the use of both physical and human resources.

The purpose of the *supply chain* concept is to integrate all the internal and external stakeholders of the company in order to accelerate the information flows and the materials flows.

The effectiveness of the *supply chain* is measured in the reduction of all the times of its processes. We move from a management pushed upstream, to a management driven by the downstream.

14.3. Product and plant design

Products, production tools (process units, plants) must be designed for the customer and for the company in respect to ethics whose essential foundation is sustainable development.

Man and his habitat must be placed at the center of the industrial plan.

14.3.1. *Products*

Product design has been described in Chapter 7 (this concept includes the principles of *Green Chemistry* and the *Green Engineering Process* taken up in the book coordinated by Martine Poux [POU 10]).

Chapter 11 provides some tools to stimulate the indispensable innovation condition so that the company can have a competitive advantage.

The *win-win* client/supplier integration is a key idea; each party having knowledge of the others' businesses and its strong points. It concerns more and more the partnership that involves a *chain of knowledge*.

The period when Henry Ford told his customers "you can have the car in any color that you want, as long as its black" is over.

The industrialist appears more and more like a service provider with an added value. He contributes to the value created by his customer; the customer has to know this.

The concept of the 3Rs [LAV 06] "reduce, reuse, recycle" is an essential concept. It can be considered as an extension of the concept of *product stewardship*; products are managed *from cradle to grave*.

A *closed circuit* can be established between the customer and the supplier; waste and used products can be returned to the manufacturer for reuse.

Recycling is about to change the nature of some industrial sectors, it already heavily impacts on the appliance and automotive market.

14.3.2. *Processes*

What has been previously said for products applies for all processes at the heart of the eponymous industry.

Technology is the basis of everything.

Good management will never replace obsolete technology. Technology is now a weapon in the global economic war and must be managed as such. It must be continuously assessed and protected.

14.3.3. *The plant of the future*

This term, which is highly-publicized and with fears of plant relocation and thus of unemployment, is a carrier of hope and a number of contradictions.

What do we dream of? Of a plant using abundant (low carbon) renewable raw materials, which consumes little energy, a plant that respects the environment, that is to say, whose environmental foot-print is low, whose investment (CAPEX for *capital expenditure*) and operating expenditures (OPEX) leaves a comfortable gross operating margin on growth markets!

We dream of a profitable plant, and hopefully a sustainable one!

As we have emphasized, for sustainable development, the concept of a plant of the future is a *compromise* between multiple criteria. It is necessary to have appropriate benchmarks. Catherine Azzaro Pantel makes this point in Chapter 8.

For example: we can build "cheap" by limiting instrumentation devices, automation and robotics, if labor is cheap. We have a transfer between CAPEX and OPEX.

We can buy cheap equipment, but what will be the cost of maintenance: not having a backup pump, what will happen to the reliability of the installation?

Electrical energy and water can be cheap and plentiful as in Canada; there are colossal coal reserves in China. Each case is a theoretical case or a special case.

NOTE.– Philippe Tanguy, at the time of the European Congress of Chemical Engineering that was held in Prague in August 2010, highlighted the relationship between water and energy. What will become of some French nuclear power plants if drought settles in?

The *location* of plants is taking on more and more importance in economies that are trying to be "circular" [PIP 10], that is where the products and energy from an installation will feed downstream installations. The new concept of the bio-refinery can be a preface for this.

We are witnessing the emergence of a concept of *regionalization* of the industry.

Energy is often of particular importance: from degraded energy, like from low pressure steam coming from HP steam may have multiple uses; process units and organizations can benefit from them.

Synergies between the process units of big industrial platforms such as those established in Germany in the 19th Century are obvious: utilities, treatment of effluents, and transport can be shared. But can we conceive it in socially unstable countries where a "minority" can block everything?

The location is strongly linked to the society, to transport *mobility*, to the quality of life (see Chapter 6).

Transportation accounts for about a quarter of global CO_2 and eco-mobility has to be taken into account.

14.3.3.1. *Other considerations of conceptual order*

14.3.3.1.1. The plant seen by the customer

The plant is made in order to serve the customers and *stakeholders*, which include the customers, they are the ones who bring it to life!

Grua and Segonzac [GRU 99] suggest looking at the factory "upside down". Instead of starting as usual, from the raw materials and coming down toward finished products, the plant is designed starting from the warehouse!

The customer is placed at the center of the productive system.

EXAMPLE.– A senior executive used to only visit administration offices and the warehouse when visiting a plant. He told the stupefied technicians that the technique was their job, what interested him was the customer.

14.3.3.1.2. Flexibility, recyclability

The *risk* related to the investment is a major risk of the company. This is the case for the highly capital-intensive pharmaceutical industry, where the risk related to the product itself (side effects) is very active before and after the start-up.

This type of risk can be mitigated by subcontracting, with *modular process units* that can at least partially be reused for other productions.

Flexibility must take into account the changes in manufacturing and raw materials. *It is no longer build for the long-term*. Philippe Escande in *Les Echos* [ESC 11] highlights the fear of companies faced with an outsider who is capable of innovating to the point of knocking down the established order. The fear is the breakthrough innovation rather than incremental innovation.

Process intensification is the subject of Chapter 12, written by Laurent Falk. This approach calls for miniaturization, aims to make the equipment parts multifunctional, and to move from batch mode toward continuous mode. We are at the clearing stages knowing that there are already *success stories* in fine chemicals.

14.3.3.1.3. Equipment and architecture

To transform raw materials one needs equipment! Distillation columns, reservoirs, tanks, pumps, exchangers, filters, dryers, pipes, structures, instruments of control, wastewater treatment plants, and so on, are an integral part of the industrial landscape and represent a significant part of the total investment.

An item of equipment is a functionality and should be viewed in this aspect. Its integration with what can be called the *architecture* of the installation, should be considered not only under process aspects, but also under the aspects of maintainability and ergonomics.

An item of equipment may be the process itself; this is the case in industrial chromatography. The synthesis of ammonia, no doubt the greatest industrial revolution of the 20th Century, was made possible by new high-pressure compressors.

We can question the impact of shortage which is looming on the horizon of some raw materials for the plants in the future.

Copper has risen from 3,100 dollars/tonne in early 2005 to 10,050 dollars/tonne in early 2011; what are the consequences to be expected if the phenomenon intensifies?

14.4. Management of production and operations (MPO)

The term "management of production and operations" is broader than production or manufacturing. Besides production, it includes all that relates to staff who coordinate, support, and manage it. It also includes purchasing, maintenance, processes, planning, management, performance analysis, and so on.

14.4.1. *Essential tasks*

The essential tasks are as follows:

– satisfaction of customer and stakeholders;

– maintaining the *cohesion* of the group and harmonious management of the operational and entrepreneurial mode;

– maintaining the *reliability* of the system (see Chapter 13);

– the maintenance of ethics;

– control to prevent major accidents, and damage to the environment and people;

– continuous improvement, quality, and cost reduction.

14.4.2. *Tools of the MPO*

– Cost accounting.

– *Scorecards* and performance indicators in the broadest sense, which range from output analysis to the occupancy rate of process units, to absenteeism, and the frequency rate of accidents.

The analysis of deviations compared with the established standards, which can be that of the budget, is of particular importance.

– All kinds of audits; those concerning the QHSE aspects have process analysis as a common point. A well-managed process unit, in terms of safety and which will be equipped with an adequate SMS (safety management system) will not have too much difficulty in obtaining ISO certification.

– The project management techniques widely described in this book.

However, let us note that the question of performance of a plant is a complex question because it is necessary to decide the measurement standards and determine the context in which the question arises: does it concern an audit of administrative procedures, a balance sheet, an evaluation of a process or an audit prior to a purchase? A very clean plant, without any accidents, can delight the corporate safety engineer, and its poor performance may discourage the financial analyst.

There is no management without measurement

– *Traceability* is becoming more and more compulsory in companies. Its objective is to know the history of a product, its origin, to identify the stages of its manufacture, and to recognize its integrity. It uses tools such as RFID, barcodes, DNA chips, and so on.

– RFID was already used during World War II to identify aircraft of friends or foes.

– In the biotechnology industry, the operating conditions of fermentation "batches" must be archived for 10 years.

– Other applications of traceability:

- location of parcels, means of transport, people;

- fight against composition fraud, falsification.

Traceability has become an inseparable part of the *supply chain*.

14.4.2.1. *Lean manufacturing*

The term "lean manufacturing", publicized by many consulting firms, implies the practices that are aiming to reduce the production costs to control the production facility, and to increase productivity in a spirit of continuous progress.

Ironically, we can say that it is a fight against *fat manufacturing* synonymous with excessive overheads, superfluous stock, and waste.

Lean manufacturing is particularly all the techniques that are related to Toyotism described in Chapter 10, often with the Western "touch" provided by the Six Sigma method. Its interest lies in the attention paid to the production function, very often neglected by many companies.

Americans point out that Henry Ford and Frederick Taylor were the first to lay the foundations of the modern plant that has replaced the mill. Value analysis, invented by L. Miles, has contributed to put the customer on the front of the stage.

The terms of *World Class Manufacturing* of *lean enterprises* cover, according to the companies, all the methods of *re-engineering* to improve profitability.

14.5. The IT revolution – IT management

It has changed the methods of engineering, facilitated calculations that took infinite time when they were made by hand, changed project management, and enabled modeling and simulation in process engineering. In the latter field, CFD (computational fluid dynamics) makes it possible to visualize the flows, transfers in dryers, fluidized beds, reactors and so on.

IT has invaded the management of the company and its facility and modified the methods of product design.

The CAx, that is to say, all that is computer-aided, gained momentum in the 1980s [BLO 99]. They paved the way for robotization which is strongly established in the manufacturing industry including the automotive industry.

The list of CAx is long! Let us cite computer-aided production management and computer-aided maintenance.

Data management, whether it is the data that a process unit continuously emits, or the information emerging from analytical instruments that detect infinitesimal doses, are possible using increasingly efficient statistical methods. It is about selecting the right methods and using them wisely!

NOTE.– A biotechnology plant of 100 million dollars has about 5,000–10,000 points of measurment. What about a refinery!

Peter Drucker [GRE 97] estimates that e-commerce is still in its infancy and it will bring a new revolution in the mode of customer/supplier relationships.

The advent of social networks is already changing the relationships between individuals profoundly and possibly between the states and individuals (see the Arab rebellions in Spring 2011). These networks will help to change the company due to the fact that nothing can be hidden for long!

14.6. And the individual?

It is individuals who "do things" that bring the company to life, who operate the production facility, albeit by remote control.

Industrialization should consider the operators, the human factor in its design phase, and in its architecture, to reuse a term which is already used. Taylorism from its aspects analyses of tasks is still valid.

We cannot think of a flexible, versatile, and agile plant if the operators – from the laborer to the executive – do not have these qualities and if they do not have the means to implement them.

The fact that the company must become an open system has changed the situation and made it more complicated.

The increasing complexity of technologies requires a continuous effort in training. The lack of growth, visibility, and the race for efficiency cause stress and eventually psycho-social risks.

It is necessary to rethink the production facilities as a source of wealth. This is not the *dirty part* [HAY 88].

Edison said a century ago: *factories or death*.

Drucker said that, in the past, knowledge was at the top of the organization, but now it is at the *bottom* with the *knowledge worker*.

For this international consultant, innovation is the key: "some think innovation is a 'flash of genius', not a systematic, organized, and rigorous discipline. The Japanese are organizing innovation. So are the Koreans ...".

Speaking of South Korea, Drucker points out that after the Korean War in 1953, the destroyed country had no industry. Currently, it is a leader in many areas ... The management of knowledge is the key as we have strongly emphasized.

It seems to us that the integration system of research and the industrial system are a basic concept, a "key idea" upon which we must build.

François Dehecq, chairman of Sanofi-Aventis, in a speech that followed the General Assembly of the Chemical Companies Association on April 22, 2010, emphasized that "there is no research center without a plant!"

During the tests conducted by Elton Mayo at the Hawthorne plant near Chicago in the 1930s, it became clear that staff motivation was improved if the staff were recognized and had a sense of belonging to a group; and from then on productivity increased.

EXAMPLE [DAL 04].– The establishment of a safety management system (SMS) in plants located in different countries of the Asia Pacific has helped all kinds of people to adhere to “a value system”. The result was spectacular both in terms of safety as well as productivity and quality.

People want to be recognized!

With all due respect, to many, Fayolism and its monolithic structure seem to be more outdated than Taylorism.

The management of change is highly significant (see the introduction to this book).

It exerts an increasingly greater pressure on the managers and their assistants [GRU 99]. This “climate of agitation” is very often a source of inconsistency, and plans after plans do not succeed. Let us remember that Toyotism took 10 years to set up itself and not without difficulty!

14.7. Conclusion

The production system spearheading the industrial company is a source of wealth and, as such, it should receive the attention that it deserves under all the specific aspects of the management, be it technical, human, or commercial [GAT 09].

Producing has become a social act [DAL 07c]; producing necessitates questioning oneself on the type of growth that will exist in any country. China cannot have the same number of cars per capita as in the United States, unless maybe the US come down to the current rate of China. Why not after all?

Industrialization, which must define the plant of tomorrow or of the future, whatever name we give it, must design a tool whose products and/or services satisfy its *stakeholders*, including customers, by implementing the principles of sustainable development with particular attention to the problems of raw materials and energy. Raw materials and energy must be available in time, in price and quality.

There is not just one plant of the future, there are many of them, even for those that make the same product. Location, capacity, and technologies implemented will influence the “*design*” of the installation.

It is easy to make up fairytales.

EXAMPLE.– In the case of a transfer of technology in China, the author had to compare two very similar process units between Japan and France. The cost comparison seemed to be inexplicable, but the result was there! The Japanese process unit had a particularly low manpower. Undoubtedly, the social conditions were not the same but the Japanese process unit seemed to be simple! The French process unit seemed to be complicated but the pumps of the Japanese plant had no spares! In the Japanese plant there were two maintenance shutdowns each year when everything was overhawled. What a lesson!

The process engineer, has a significant role to play in the industries of transformation of matter and energy, industries that will shape our very near future at a time when an international awareness seems to be emerging.

"*We are in the right profession*", said Dr. Richard Darton, President of the EFCE (European Federation of Chemical Engineering), who wrote the preface for this book.

The process engineer, in order to be effective, must have a systemic vision, know the geosciences and the machinery of the modern company.

After the technical engineer of the 19th and 20th Centuries, the era of the *citizen engineer and manager* has arrived.

This book is dedicated to him.

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