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Bonelli 4.0: R&D to Interconnecting Machine, Layout and New Type of Production

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Abstract

Bonelli 4.0 is a project intended to study new technologies incorporated in the spaces of a highly innovative company; Bonelli produces wooden fixtures. With the introduction of the Homag machine, the company has studied a new productive layout, improving the production system itself e totally re-modulating all the work commission management. In addition to the developed layout, the study has defined a new logic and a new process not only aimed at the highest quality, but also at the realization of a highly specialized and mechanized prototypical system. The machine in fact, as well as reducing the lung area and the warehouse (no longer present), has allowed by tests to create an innovative management of the fixture project. Indeed, compared to before the usage of Homag and Archimedes, the commission was managed in a traditional way with a really long series of steps. Today, however, it starts from the yard already with the defined project, ready to start the production. The testing has also proved, by the new design, three successful elements of the project itself:

• Improvement of the productive process
• Reduction of the processing time
• Increase of the global safety conditions at work in the company.

Keywords: Wooden fixtures, layout, engineerization

1. Introduction

The industrial and artisanal production plant is a complex of machines, equipment and facilities which allow the processing of raw or derived material into finished products. It is part of a complex productive process which is called business or company, generally aimed at achieving of economic targets, gaining final goods (products or facilities) more valuable than the starting raw material or goods, in order to produce a profit, covered all the production costs. In the industrial and artisanal production plant can be observed, in addition to one or more production or technological plants, also several complementary service plants, each one designed to the satisfaction of a certain need of the production process. The study has considered both the technological and service plants [1-14].

In more detail we can say that: the technological plant is the set, more or less complex, of machines, equipment and devices which allow the real processing of raw material into finished product; so it is realized the "technological cycle"; the services plants are complementary because they allow the functioning of the technological plant; every service plant accomplishes the satisfaction of a certain need (hydraulic system, electrical system, compressed air system, steam system, tech system etc.

In fact, the production plants are classifiable (Picture 1) according to several analysis criteria:

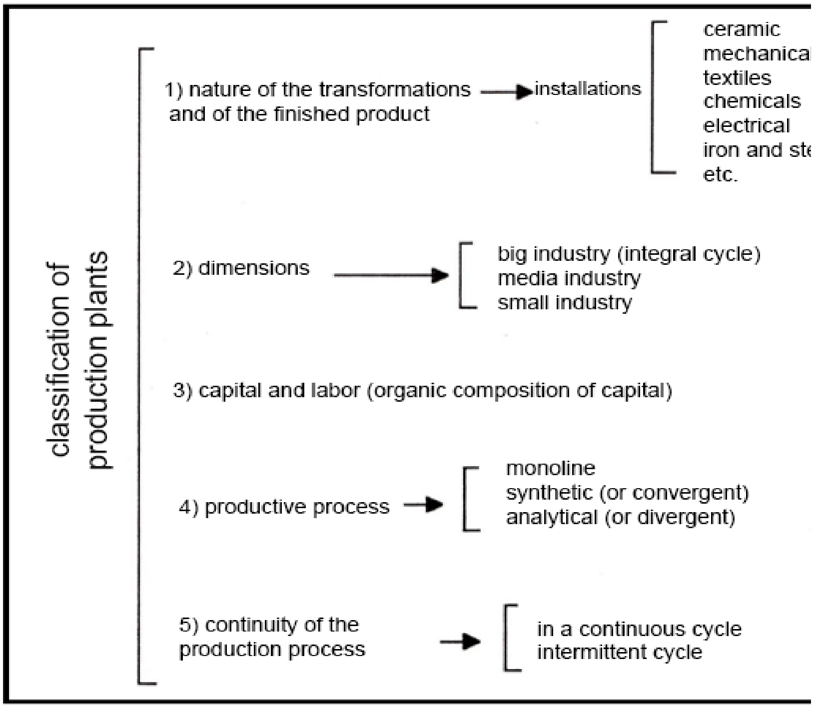
1. According to the nature of the transformations and the finished product it is possible to distinguish mechanic plants, chemical, construction, electrical, steel, food, ceramic, cement.

2. According to the size it is possible to distinguish plants belonging to "large, medium and small industry"; criteria to evaluate the size are several: number of workers, invested capital, productive capacity (or potentiality), etc.

3. According to the capital and to the work, along with the raw material and the energy, it is possible to distinguish "high intensity capital plants" and "plants with a predominant content of work"; defining the R parameter "organic composition of the capital", as well as the relation between the fixed capital (related to the set of means of production) and the variable capital (related to the workforce), it indicates that high density capital plants are characterized by high R values, on the other hand plants with a predominant content of work are marked by low R values. R values are very variable from a sector to another. It is notable that the general trend in capitalistic production (and this is in common in every sector) is to reach certain R values even higher, replacing human labor with new machines.

4. According to the technologic diagram, or production process, it is possible to distinguish "mono-line" production processes, in which the output of each operation passes entirely through the next operation (cement production, cast iron production, etc.); "synthetic or convergent" processes, in which raw material and parts converge from different operations in the final stage of the process, which is

often the assembly (electronics, cars, electron, etc.), subject of study and experiments; and “analytical or divergent” production processes, in which from one or little raw material it is possible to obtain a lot of different products (petrochemical, furniture, pharmaceutical, etc.). 5. According to the continuity of the production process, it is possible to distinguish “continuous cycle or flux” plants (blast furnace, cement factory, refinery) and “intermittent cycle” plants (redundant production for batches, variable cycles production on commission depending on customer’s needs).



Picture 1 diagram of abstract analysis used

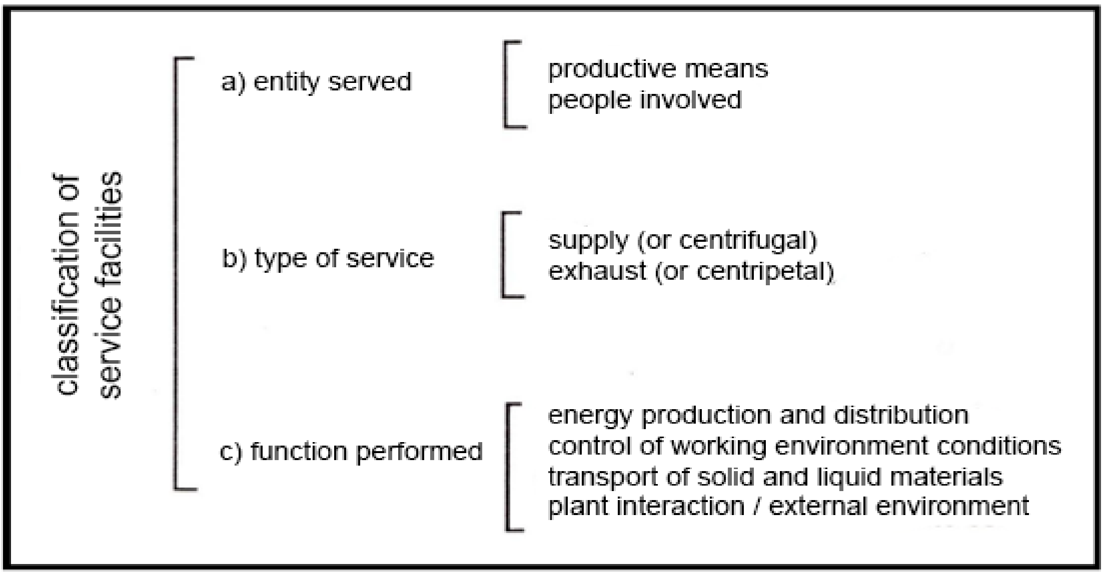
Service plants, as stated, are complementary plants, included in industrial plants, but not directly taking part in the production, aimed to one of the following targets:

(i) Power supply of electric and/or thermal energy to technologic plants;

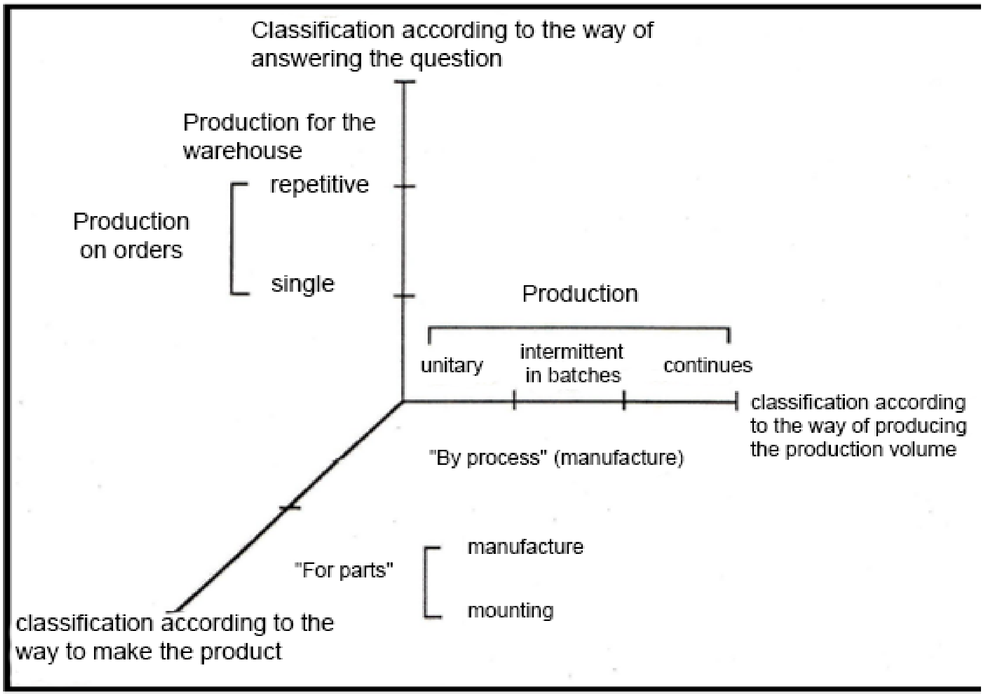
(ii) Power supply e discharge of solid and/or liquid material;

(iii) Realization of adequate environment conditions for the production or conservation of goods and ensuring the physical health of workers;

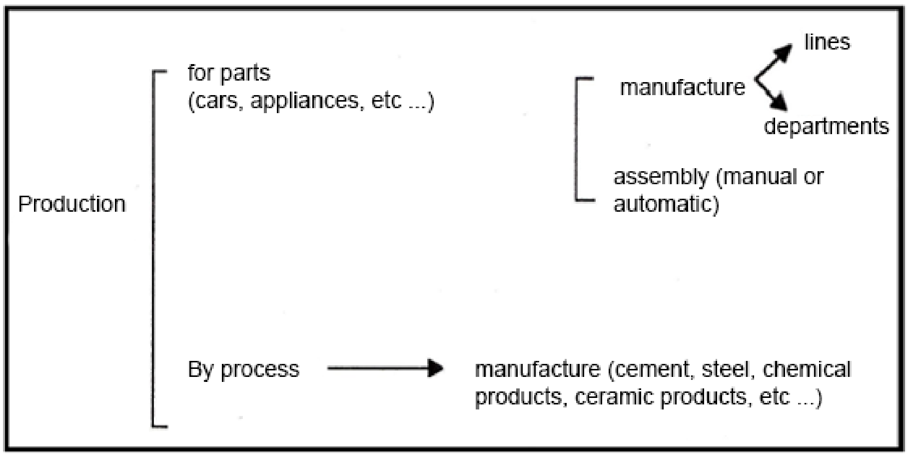
(iv) Realization of hygiene and security conditions both inside and outside the plant.



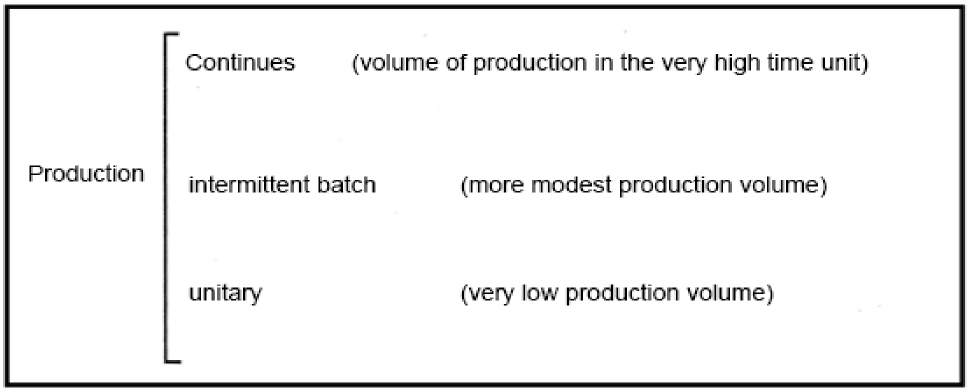
Picture 2 service plants classification



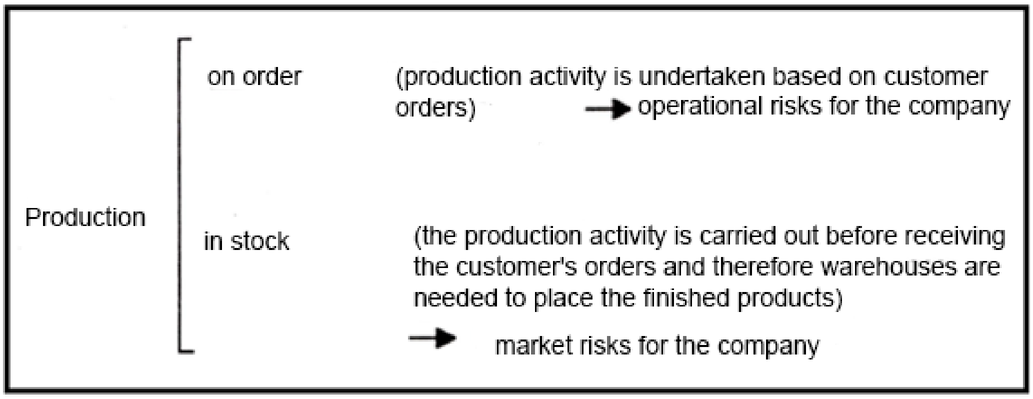
Picture 3 classification of the different production types in industrial and artisanal sector



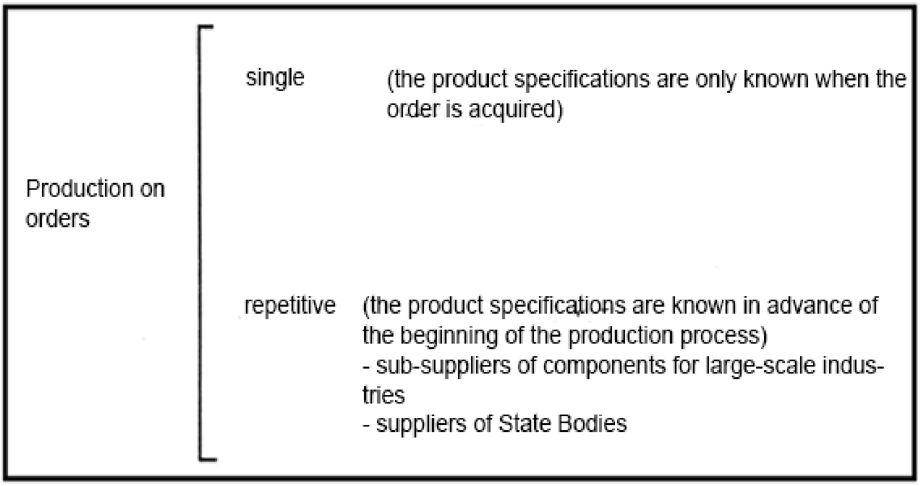
Picture 4 scheme a) conceptualization and diagram of flux to generate the layout



Picture 5 scheme b) conceptualization and diagram of flux to generate the layout



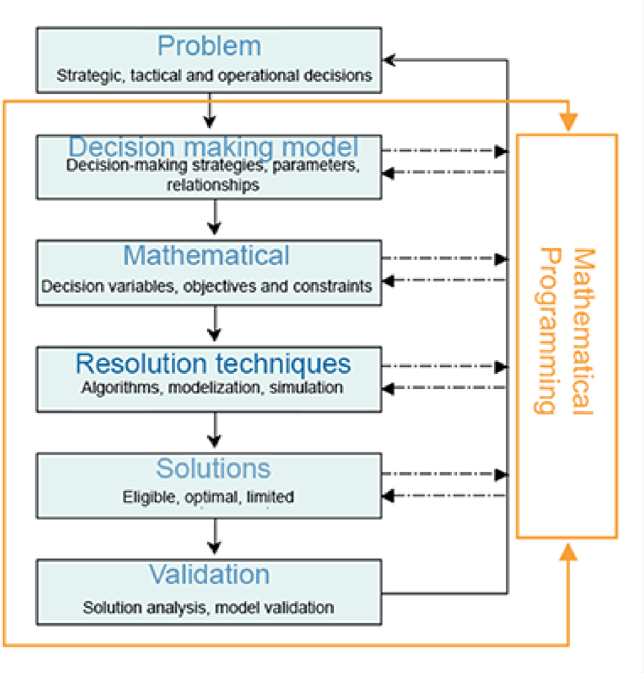
Picture 6 scheme c) conceptualization and diagram of flux to generate the layout



Picture 7 scheme d) conceptualization and diagram of flux to generate the layout

When making decisions, so choosing the best alternative among the available, the man always uses, more or less consciously, a model, which is a simplified but efficient representation of the very reality. Among the generable models, are relevant the mathematical models, whose characteristic is to give a mathematical structure to the problem, or even algebra, which allows to examine a high number of possibilities, to analyze the sensibility to the change of environment parameters and to evaluate the existence and the calculability of a solution. A very high number of problems about the detection of decisions with different restrictions can be modeled and solved with the proper methods of the mathematical coding, term which define the research of an ideal solution by using mathematical models.

Its applications in the real world are from the finance to agriculture, from the planning of industrial production to the distribution of electric energy and to the networks study. The logic approach which solves decisional problems by the mathematical coding is known as modelling organizational approach, and it has two different stages of real problem analysis: representation by a mathematical model able to identify the parameters and the significant variables of the problem, and the relations between them; utilization of solution algorithms to identify a solution for the problem and evaluate its efficiency. In order to produce a study which has scientific importance, the research team has identified as development model the logic scheme represented in Picture 8 [29-31].



Picture 8 modello per lo study realizzato

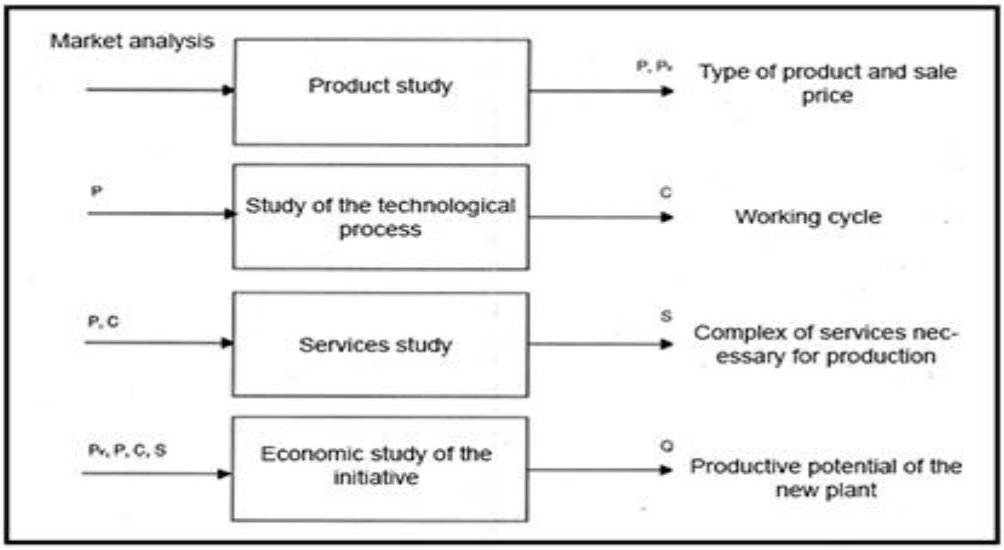
The structure of a production system is very conditioned by three fundamental variables: at the beginning the interaction with the providers; in the end with the customers; and the characteristics of the product [19-26].
The first two represent the interaction of the production system with the outside and they generate a change of the internal structure for a better interface with the environment. The third represents the peculiarity of the object of the production, around which is built the production process in order to achieve the product conformity for the specific requirements. The strategicl parameters of the production are the internal variables on which the company can operate to create an action that can generate an external competitive advantage against the competitors.

In 1984 Hayes and Wheelwright, then Gunn in 1987, proposed some key elements origin of the competitive advantage:
• Production Capacity;
• Service Level;
• Technologic Level;
• Integration Degree;
• Workforce;
• Quality;
• Production Plan;
• Organization;
• Flexibility;
• Stock rotation index.

Important characteristic of these parameters is being quantitative indicators, being possible to improve, so optimize, the company performance only when it is measurable. Within the study these parameters along with the elements defined intangible will be used to define the impact on the company system and the new features to interconnect the machine. The study made within the company has detected the following analysis and the operative stages developed both inside the internal research work and from the consultancy activity and external research: study of production system re-design relative to a new machine; R&S aimed to the interconnection between the company software Archimedes, company layout and new type of production to evaluate and improve the production system Homag [15-19]. When it is necessary to design a new production line-up or to modify the company layout. In detail, the manufacturing companies management takes place by the detection of choices which, depending on the time horizon where are projected, and depending on the participation of the different company levels, can be divided in:

- Strategic: they are the decisions made at the highest decisional level. The target is to define the strategies to apply, so the characteristics of the project to realize.
- Tactical: they are the decisions made at the medium decisional level, about the demand and the services management. At this level generally is planned the plant layout, the material management, the resources allocation.
- Operative: they are the decisions made at the most internal decisional level, regarding the physical realisation of the product. Usually the decisions involve the choice of the plant sizing and scheduling.

In case of complex organisations, generally the production systems, but the strategic targets can’t be achieved immediately but they need to be translated in sub-targets more operative and detailed: company politic formulation, operative plans, procedures and rules. In the management process, it is possible to distinguish different hierarchical levels: from a level to the next, superior targets (strategic decisions) are divided in sub-targets; the abstraction degree decreases (abstraction of realisation details) and the operative and procedural aspect increases (passage from what to how). Every stage has to achieve the targets of the hierarchical upper level, using the tools provided from the lower level. Strategic targets are wide-range tools with a long-term prediction, otherwise plans, programmes, and procedures have a level of detail even higher (Picture 9) [34].



Picture 9 analysis scheme for the certainon of performance and project logic

The management is a dynamic process which uses different abstraction and aggregation levels both to simplify the problem complexity, and to face the different degree of available information on the timeline.
A lot of information are available just in the immediate temporal proximity of the events; instead they are very little at the time of the formulation of strategies, due to the temporal distance which separate them from their target.
The strategic plan is the furthest from its target and the typical size of its temporal horizon is 3-5 years. The plan fulfilment passes through the formulation and the achievement of several company plans: marketing and sales plan, research and development plan, financial plan, production plan. For each of them there is another division; regarding the production plan there is an aggregate plan (1 year), a main production schedule (Master Production Schedule, 3-6 months), an eventual

schedule of assembly (1 month) and finally the operative control (continuous).
Depending on the tactic and operative choice levels, in every stage of the management can be found three key times:

• The plan. Plan means the management function, whose task is to select the targets of an organisation and to establish the strategies, the policies, the procedures, the schedules and the projects needed to their achievement. More particularly, production plan means the function which defines the global production level.

• The schedule. Task of the schedule is the translation of a target in a plan, using the available tools of a certain hierarchical level. So, the schedule is the activity which defines what has to be done, in which quantity, and with which deadlines. The activity of schedule follows logically the plan activity beacuse its target is to make operative a target of which is known only the viability. The elaborated schedule has to be viable and the best among the possible choices, able to take the best advantage of the assigned resources. The elaborated schedule at a certain level, in addition to representing the output of a certain stage, represents also the input (targets) of the next level.

• The control. The difference between schedules and reality is inevitable, so it is necessary to include a control stage which has the aim to give the necessary information to lead the correction actions. The control is the production function which controls the trend of the activities in relation with the production schedule, it marks promptly the serious divergences and makes the interventions indicated by the management.

2. Materials and methods

In terms of methodology the study made within the company has seen the following analysis and the operative stages both developed within the work of internal research and by the consultancy activity and external research: study of re-design of the production system depending on a new machine; R&S aimed to the interconnection between machine, company layout and new production type.
In this paragraph will be illustrated the main qualitative methods present in literature, by which it is possible to evaluate all the types of intangibles in the company. These methods have the aim to describe the immaterial assets owned by an organisation without using metric which express its financial value. If you want to obtain numerical indicators from these methods to allow the monitoring in the time of a company or the comparison with other organisations, it is necessary

the direct intervention by the analyst. As will be seen, the most used methods to “convert” a qualitative method in a series of quantitative markers are basically two:

1. Likert scale: the analyst expresses with 1 to 5 (or to 7) values the company situation for a specific aspect. For instance, if we consider the territorial coverage by the company shops, will be assigned a value from 1 (zero coverage) to 5 (complete coverage);

2. Excellent report: it is based on the determination of an optimal value with respect to which to define the condition of the company. Returning to the previous example, we will define the optimal value (1 store for every 50,000 inhabitants) and what describes the current situation of the company (1 store for every 250,000 inhabitants) to then report them and understand what the current condition is in relative terms (20% of the optimal value). Because of the contribution required to the analyst, qualitative models are affected by greater subjectivity that can be reduced, but not eliminated, through the use of evaluation teams. Another factor that helps to reduce subjectivity is fragmentation: assigning a value from 1 to 5 to the Human Capital of a company is much more complex than evaluating its sub-components (the average age of the workforce, the degree of education, the confidence of the operators with certain technologies).

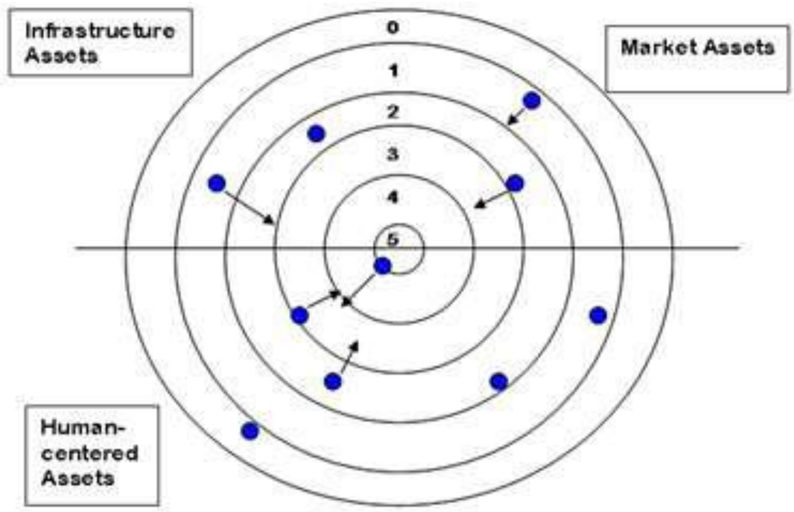
According to Brooking, it is crucial for companies to determine their wealth in order to make management understand the true value of the organization, to define success and growth and to support loan requests to credit institutions or innovations and production processes integrated into the company.
The proposed method consists of the following phases:

1. Understand which changes are necessary to reach the targets of the evaluation;
2. define the sector and its limits;
3. define the intangibles of the organization;
4. determine the optimal state of each aspect of the identified assets (the optimal function will be the evaluation parameter of the IC Audit evaluation);
5. choose the most effective Audit method among the 30 methods defined by Brooking (1996);
6. perform the verification of every aspect of the identified assets;

7. Enter data in a database where the entered values are normalized in a scale from 0 to 5, where the maximum corresponds to the optimal state;
8. Represent the values on a target where each point represents an asset and while the arrows indicate how they should be positioned;
9. Determine the financial value of each asset according to cost, market and income approaches.

The Brooking model is very effective for identifying strengths and weaknesses in terms of assets, given the very intuitive nature of target representation, and allows the simultaneous assessment of all intangible assets.

The main criticism of the IC Audit model is the lack of clarity in the financial assessment phase that does not allow the determination of an effective measurement of the value of assets.



Picture 10 Brooking target *(Source: Knowledge Management for Community Development, http://www.aijc.com.ph)*

Viedma's main interest was to define the competitive gap between the company and its competitors on a global scale. This gap concerns every business unit and, through the comparison with competitors, Viedma believed it was possible to

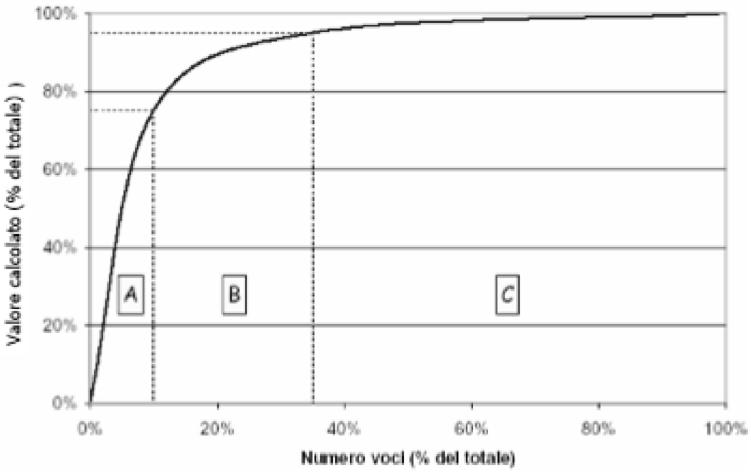
understand how to manage Intellectual Capital in the most efficient way and how to facilitate the learning process for overcoming the gap.
Intellectual Capital Benchmarking System is a system in which the judgment on the analyzed structure is generated on the basis of comparison with similar competitors. The method uses a general model of business excellence in order to identify the key factors for the comparison.

There are three generic business models: one for operational processes, one for innovative ones and one for share capital. From the general model, specific models were also created for each business unit of the organization in which the business success factors were identified. The different organizations will then be compared on each of these success factors, measuring on a scale from -5 to +5 if the company object of the analysis was operating better or worse than another reference competitor.

This measure was also associated with an estimate of the accuracy of the response on a scale from 0 to 100 that allowed the creation of an index of reliability of the assessment which constituted the first result of the analysis. The second was the subdivision into two groups of factors: the positive ones, in which the company had an advantage over the competition, and the negative ones. From this subdivision it was possible, through a system of weights, to create a weighted average value of the performance of the company in relation to competitors. Although the model is very useful for determining the performance of the company in relation to the environment in which it operates, the analyst's discretion entails an excessive subjectivity of the results and the impossibility of using the method within an absolute evaluation.

2. The criteria and methodologies for the conceptualization planning of the production process

For the development of the project the following variables and methods were considered:

1- Plan layout design, internal logistics organization, plant services • General criteria for organization and management of production; • Planivolumetric organization of the plants; • Numerical methods for the design of the lay-out in function of the transformation cycles; • Simulation and optimization models in layout design; • Criteria for the design of the establishment services. Production processes A general classification of production processes is based on three main elements: • DIFFERENTIATION and number of products belonging to the range; • degree of STANDARDIZATION of the products and size of the flows with which these are placed on the market; • how the DEMAND is manifested (production "on order / pull" or "per warehouse / push").	2- The management of the materials. • Analysis of cost factors in materials management; • The ABC method in the evaluation of stocks Picture 11;  Picture 11 Sample model of ABC stocks • Mathematical models for determining the optimal lot of purchase; • Mathematical models for the determination of the optimal production lot or the safety stock; • Material with dependent and independent demand; The MRP; • Roc and Rol models in the management of materials with independent demand; • Current models of material management under zero stock (Just in Time).
3- The Plants Maintenance Service: • General design and maintenance management criteria; • Choice of maintenance policies; • Maintenance work; • Outsourcing.	4- Quality Management: • The quality of the company; • Organization of the control quality service; • Statistical methods for control quality; • Control cards and process capacity indices; • Methods for improving quality.
5- Ergonomic aspects in the design of workstations: • The reference standards; • Ergonomic reference standards; • General planning criteria for work postactions; o Usable simulation software; • Case study.	6- Workplace Safety or Legislative Safety Issues, Legislative Decree 81/2008 • Guidelines for risk assessment; • Risk mapping and security plan; o Individual protection devices; • Management of internal audits.

The production cycle is imposed by the material transformation technology of the materials (physical and chemical aspects); from the strictly unitary technical-productive system; and from a set of technically distinct machines (non-modifiable sequence, obliged by the transformation techniques of the food-material industry, textile-operations in obligatory succession).
Furthermore, there are different types of production processes:

• on-demand production process (job shop)
• batch production process (e.g. Machines and homogeneous operations for functions; Production range);
• production process in line conditioned by the characteristics of the workforce;
• production process in line conditioned by the characteristics of the plants (e.g. Relevance of the combination of the type of production with the standardization of the cycle and the arrangement of the plants; Investments in plants and equipment; Stocks of safety; Optimization of production flux);
• continuous production process (eg Unica variety of products, uninterrupted flux of material up to the finished product (absence of intermediate semi-finished stock) continued technical-production cycle, pre-defined and stable production scheduling, little labour, vertical upstream integration as providers).

The layout concerns the planimetric layout of all the resources necessary for the development of the workings and includes the design and positioning of the spaces, buildings, plants, in line with the production system and the material flux. The target achieved within the project has seen the following elements: maximizing system productivity; maximize use of plants / machines; minimize material handling; minimize stock volumes, semi-finished products, products; maximize flexibility in production processes. The different types of layouts applicable to production are identified below according to the experimental phase. The provision "by department" provides that the machines are grouped into specialized departments and the operations are independent: different production cycles that are carried out simultaneously.

Altre tipologie di layout

The solutions "by department" and "chain" represent extremes and no company applies them individually in an absolute way. In reality plants are rare in which the disposition is merely "chain" or "by department", but rather a combination of both. Disposition of the machines to "Group Technology" Cellular manufacturing (production for cells).

Type	Machine arrangement	Process	Degree of flexibility	Materials and stocks	Degree of control
By product	Chain arrangement - same sequence of machining cycle operations	Continuous process, strong specialization and mechanization	Low (production rigidity)	Mechanized movement reduced to the minimum	Medium, greater risk of machine failure
By process or department	In groups for homogeneity of operations, highly specialized depart-ments	Intermittent	High, vast combi-nations of produc-tion cycles	Significant move-ment of materials and relevant intermediate warehouses	High, with reduc-tion of machine damage risks
To technologi-cal groups	Working cells (components grouped into families for homoge-neity in the techno-	Intermittent + continuous process (maintaining flexibility with advantages of specialization)	High + low	Medium material handling	High
Fixed position	Equipment, materials and people revolve around the product	Custom production (naval and civil engineering works)	High	Limited handling	High
					20

Table 1 Models of analysis production, product layout

At the methodological level, the last part of the research will develop the area of the interconnection between production system and machine. Interlinking and digital integration with the company means all integrated IT systems in order to guarantee the following aspects between machine and factory:

- Interconnection to factory computer systems with remote loading of instructions and / or parts of schedules;
- Automated integration with the logistic system of the factory and / or with other machines of the production cycle;
- Development of the layout of the machine in function of the interconnection of the company; Integration between physical machine and / or plant with the modelling and / or the simulation of its behaviour in the development of the process (cyber-physic system).

3. Results

Most monetary quantitative methods involve the introduction of assumptions and simplifications that at the application level are very difficult to implement: determine the percentage of profits generated by an asset or its market value, predict the income that can be generated by an asset, estimate replacement costs. Likewise, some non-monetary quantitative models also appear to be complex in their application: Brooking's IC Audit model and Kaplan and Norton's Balanced Scorecard, for example, require the determination of the optimal level of resources,

but do not specify what the criteria for the definition of the excellent. This implies, therefore, the introduction of a degree of unavoidable subjectivity and, possibly, reducible through the use of evaluation teams that can establish the optimal level based on the comparison of several analysts.
Relying on exclusively qualitative models, due to the simplifying assumptions that they introduce, can lead to inaccurate evaluations, and even more distant from reality, the greater the complexity that has been tried to reduce; nevertheless, in these models we find the possibility of understanding in more depth the company dynamics and of evaluating, as appropriate, the real need for a company to have certain strong intangibles. We will then proceed with a qualitative analysis of the company.
The experiments will be used to understand the position of the company with respect to certain aspects and will use, as a guideline, a list of aspects defined ex-ante that are considered to be suitable factors to describe the strength of the company with respect to important assets for the sector. It is therefore possible to highlight which are the intangibles on which it is considered appropriate to concentrate the analysis.
The assets that will be analysed will be:

• Human Resources and the set of knowledge, skills and attitudes with which the company can realize its business;
• the Protected Organizational Capital, in particular the brand and the unprotected Organizational Capital;
• Infrastructural Capital seen as a set of processes and systems.

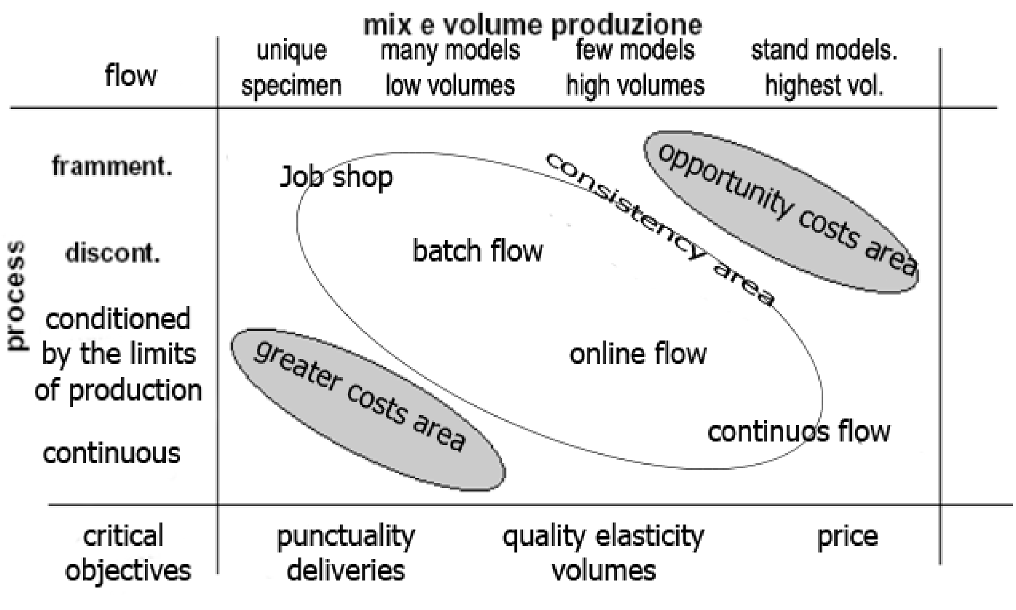
The presented method of analysis is based on the use of the principles underlying the evaluations through the Likert scale). These techniques, commonly used in the company's consulting environment, are the basis of many methods of assessing intangibles that do not appear in the literature as they are fundamental tools for the core business of the companies that make them. It is also necessary to remember that these methodologies are generally structured ad hoc for a single company or for the sector in which it operates and therefore would not make a real contribution to the study of the subject, if not for the analysis of specific cases. What we intend to achieve with this study is therefore an analysis tool that allows us to evaluate the strength of the intangibles within the company strategic-operational context.
The evaluation of the force will be carried out by assigning to each considered aspect a Likert scale value, according to the judgment that may be "low-medium-high" on the match found between the company condition and the considered factor. For example, if we consider the territorial coverage with single-brand stores we can define low-medium-high in function to the degree of coverage of

the competition and to the needs detected by the company. The model used in this analysis broadly incorporates the concepts underlying the Brooking model. Overall, the company has medium-strong intangibles and, in particular, is very strong for what concerns the technological part and the development of new products.

3.1 Study of the production system design

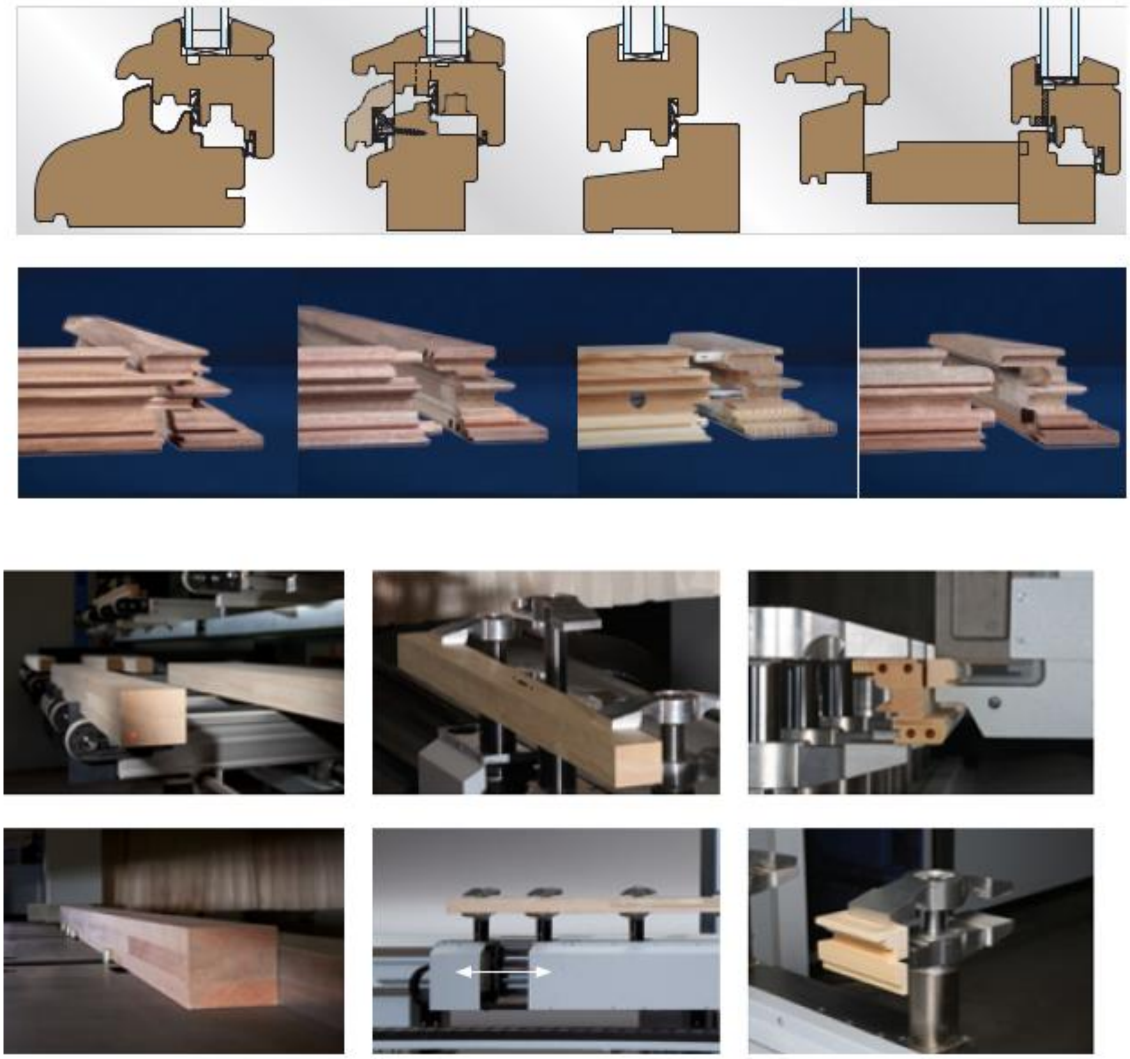
The design of the plants for production lines in the company has several difficulties:

• Operations not always automatable;
• Manual finishing;
• Modular assemblies by type, conformation and number
• Types of flows and processes.

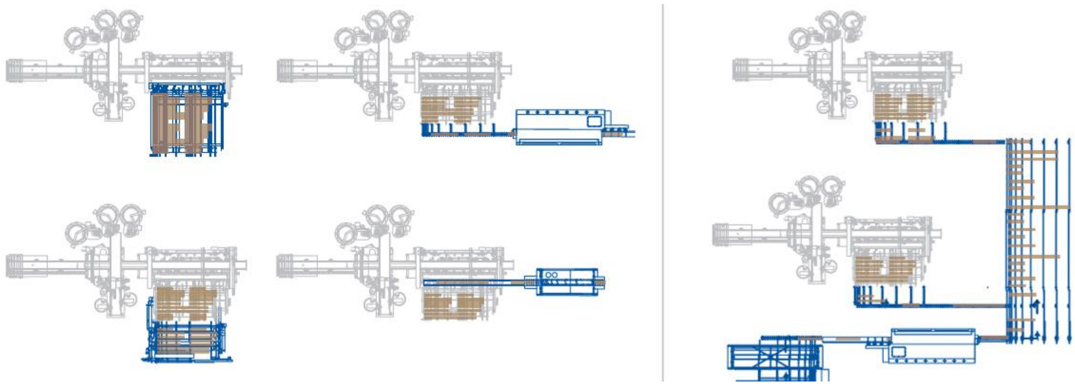


Picture 11 Variables analyzed

Furthermore, the specific design must take into account the logic and the company choices that determine the type of production and product in the following figures, which shows the positioning of the company relative to both the production flux and the type of production. The machine defined as an experimental choice is a technically interconnected machine that can handle a series of extremely complex operations. In fact, the machine is a complex station with multiple milling and handling elements which can pass from a "defined cubotto" blank piece to a perfectly machined piece and integrated into a design scheme.

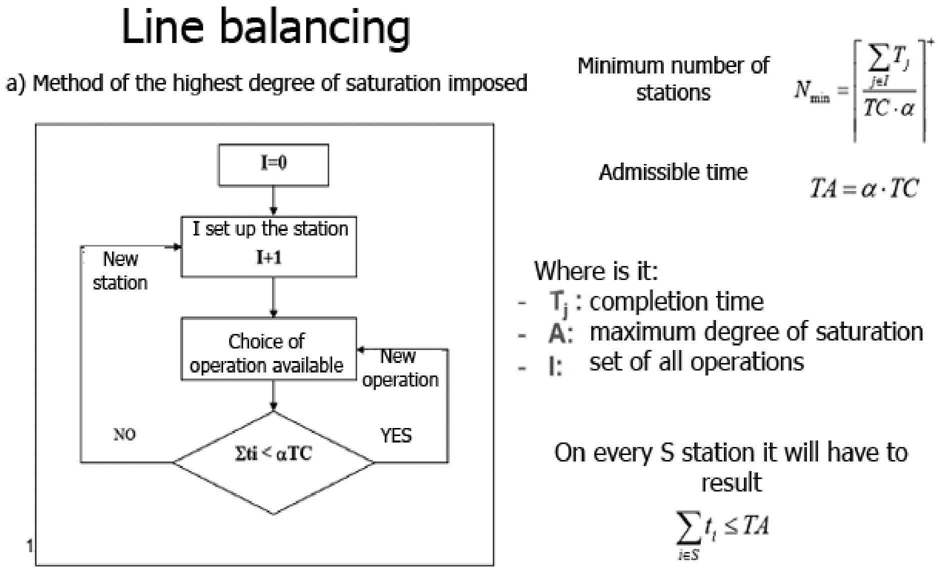


Picture 12 working examples



Picture 13 Examples of with Picture on specific proposals for the machine in question

The mathematical formulation given to the sizing problem of a production line is of the whole number (integer scheduling) class. The problems belonging to this class are recognized as difficult problems, being in their generality belonging to the category of NP-complete problems. However, it is not certain that a particular formulation of a problem through the integer scheduling is not then easy to solve, or for some specific instances, or for some particular structural properties of the problem. To show how the problem of sizing a line is in fact difficult, we consider a special case of the problem in which there are no precedent relations between the tasks. The problem then comes down to inserting the largest number of tasks in the least number of stations, in whatever order this is done, and therefore is due to the well-known problem of bin packing, which turns out to be NP-Hard. Therefore, even the problem of sizing a line belongs to this category. In fact, even if it is not to be excluded that there can be a simpler formulation, the problem is still due to an NP-Hard problem. Moreover, the problems of this category are linked together in such a way that, if it were possible to find an easy solution for one of them, then it would be possible to find them for all the others, and this method has never been identified in many years. Of research on many different problems. The difficulty of the problem, therefore, justifies the use of heuristic algorithms, such as the RPWT or the COMSOAL.



Picture 14 splitting the balancing process of a line (NP-Hard problem).

Briefly, it should be remembered that the heuristic term, from the Greek euristikein = to discover, indicates an (algorithmic) method for the search for admissible solutions (not necessarily very good!) Of an optimization problem.
In general heuristic techniques are based on a procedure that involves the following logical steps:

a) Assign a weight to each task;
b) Update the set of admissible tasks (i.e., those whose predecessors were all already assigned);
c) Assign to the first available station the admissible task to which the greatest weight corresponds without violating the maximum capacity of the station and the precedence constraints.

The layout design of a plant industrial consists in the localization of n machining centres (departments) in a warehouse of a given area. The need for the layout study is also presented in the redesign for the expansion, modernization, reorganization, production conversion. The fundamental targets followed in organizing a plant layout can be summarized as follows: Place the work centres as close as possible to each other in order to reduce the amount of semi-finished products moving along the connecting ways; Reduce the number of stops and stop times of semi-finished products; and Increase the level of automation of the materials handling equipment inside, making more frequent use of self-propelled vehicles.

There are numerous algorithms and automatic calculation procedures for choosing the optimal planimetric layout of the departments and machines. Some algorithms are based on the graph theory as we will see from the proposed solution. Others are based on linear scheduling models similar to transport problems. The problem can be described by means of a graph G (V; E) whose nodes represent the machining centres. Two centres (nodes) are adjacent if a non-zero quantity of material is exchanged between them. To each arc (i; j) is associated a weight with proportional to the quantity of material exchanged between the centre i and the centre j. This weight with can be represented equal to the product between the volume flux and a unit cost "hij" of material handling. This cost includes various items including the cost of equipment for material handling, labor costs, and the cost of inventory for the product in transit. We can also think of incorporating factors related to the safety and importance of the customer.
If all movements are of equal importance, the weight hij = 1 can be set.
What can be useful to understand before designing a layout is the possible presence of a dominant flux, of a few dominant flows or the absence of dominant flows, that is to say the quantity of flux that is exchanged between one department and all the others. departments is almost the same.
To do this you can define the following parameter:

$$f = \frac{\sqrt{\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}^2 - n^2\bar{w}^2}{n^2-1}}}{\bar{w}} \tag{1}$$

Where:

$$\bar{w} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}{n^2}. \tag{2}$$

Experimentally, values of f > 2 indicate the presence of few dominant flows, while values of small f, close to zero, indicate many almost equal flows. Values of f close to 1 generally indicate problems of high difficulty. Finally, the value of f can be calculated in the following way:

$$f_u = n\sqrt{\frac{n^2-n+1}{(n-1)(n^2-1)}}$$
$$f_l = n\sqrt{\frac{1}{(n-1)(n^2-1)}}. \tag{3}$$

The solvability of the problem of searching for a layout that maximizes exchanges between adjacent centres is linked to the concept of planarity of a graph. A graph is called planar if it is possible to draw it on the plane so that its edges do not intersect. If the graph is planar the problem can be solved effectively by calculating

the dual graph. Vice versa, the problem under examination becomes difficult and resolves to the excellent with enumerative or heuristic techniques that allow to obtain, according to the rules implemented, different planar graphs starting from the initial graph.
The general procedure concerning a layout project is shown below:
The discussion will provide the introduction of constraints that will be characteristic of an online or island production process are the decisional variables that manage this problem. These two ingredients will give rise to the mathematical formulation of the problem of the minimum number of working stations and of the correct interface between production machine and operator. The connection levels considered within the study are provided at a conceptual level.

<table>
<tr><td colspan="2">Kt: element linked to production time
Lnf: linearity of flux
Rpomag: Reduction of the spaces destined to lung areas
Gslsic: Increased security
All: transfers to the production area
The algorithm generation algorithm for the company is then defined by the following parameters:
layout= Kt*lnf*Rpomag*Gslsic* All</td></tr>
<tr><td>From the Picture in the pre-design phase and the Homag installation emerge the following considerations. Flux not organized with processing and production islands not interconnected.
The workpiece processing is then carried out on small stations such a setting determines:
• increase in working time;
• increase of the lung spaces with great need to move pieces during the processing phases;
• increase in dustiness;
• increase in travel;
• increase in the complexity of the flux with zones of loops and areas of intersection between different zones and areas of production;
• difficulty in managing the entire production area in an organic way;
• Area difficult to manage in an organic way;
The study made it possible to optimize the installation of the Homag machine according to the following specific factors proposed in the algorithmic descriptive model.
layout= Kt*lnf*Rpomag*Gslsic* All
The installation of the Homag machine has significantly affected the Kt factor; the technical and structural motivations are illustrated below. According to the experimentation, Kt assumes a strongly positive value by halving the travel time and workpiece processing (the Homag can perform a series of movements and workings while keeping the piece in its position).</td><td>Lnf: the development of the test activity has also defined an absolutely linear process with the following logics:
- pre-project and project (Archimede)
- order
- warehouse
- Homag machine
- assembly
- painting
- final assembly.
The construction phase that in the previous layout was primary and carried out in a randomized way now and traced and only occasionally on non-coded pieces or on test, is only partially used for the pre-project flux conception.</td></tr>
</table>

Rpomag: as evidenced by the comparison of the two states of the art the production system has been completely redesigned with the following specifications: 1) reduction of warehouse space and non-productive areas 2) absence of lung area with highly linear flux 3) absence of dispersion in logics of island production or non-coded process finishing point.	Gslsic: occupational safety management. In this context, the main phases of maximum performance of the developed project are reported: • dust reduction; • Reduction mmc; • Reduction of mechanical movement of loads; • Reduction of mechanical risk; • Reduction of the risk of handling and cutting; • Noise factor and vibrations reduction (Homag partially enclosed and closed machine). All: the part handling and cutting phase takes place mechanically, almost completely reducing all the parts moving parts.
If we consider an index of 0.1 to 1 of performance we can define in semi-quantitative way the evaluations between the two algorithms (a): Ante experimentation and (b) post experimentation. layout= Kt*lnf*Rpomag*Gslsic* All (a)=0,2*0,4*0,1*0,7*0.3= 0,0017 (b)=1*0,8*1*1*1= 0,8	

3.2 R & D activities aimed at interconnecting all the company areas and the new machinery related to the planning software

A further element that has a certain impact on the aspects of management and development of the company layout in particular on the factors Kt, lnf, all has been the use of a management, design and development system related to the Homag machine, in particular the Archimedean system.

Specifically, the system allows to:

• activate the planning already in the construction phase;
• Define only one step with the designer;
• Simplify the movement of pieces in the company;
• Eliminate changes and retraining in production
• Improve the performance of the entire system
• Reduce production time and costs (currently less than the pre-project situation (n) the work phases and the n-3 steps.

All the engineering and experimentation activities have therefore led to the following results:
• maximization of the production process;
• reduction and efficiency;
• improvement of the production logic with the intervention of high performance systems both external and internal.

4. Conclusions

From the study conducted, factors emerged that the company has developed within the experimentation and research session that are in fact fundamental for the competitive advantage. These are, in order of recognized importance:

• Production flexibility;
• The quality of production technologies;
• The capacity for innovation;
• Increase of safety levels at work;
• Generation of an interconnected layout to both the machine and software part present in the company;
• Correct management of production flux with optimization of all production phases;
• Model and algorithm representative of the production reality.

Efficiency and connection between the machine and plant structure with particular reference to overall efficiency. From the research carried out and from the tests we can therefore summarize the main results that emerged: possibility of increasing the quality and efficiency of the installed machine in relation to the designed layout, in particular the development of the layout studied while increasing the impacts on all company aspects (tangible and intangible) maximizes technology innovation and competitive advantage. Furthermore, from the studies it is fundamental to choose the parameter all that determines the main result of the company both the degree of interconnection of the system and the effectiveness of the new machine and designed layout.

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