

People's Democratic Republic of Algeria
Ministry Of Higher Education and Scientific Research
University Of Echahid Hamma Lakhdar El Oued



MAINTENANCE STRATEGY **Course**

Presented by: Dr. MENECEUR Redha

**Specialty: Maintenance
Industriel Level: 1st Year
Master MI**

2024/2025



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Department of Mechanics
Faculty of Technology, University of El-Oued**

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Chapter 1. Functional Analysis

1.1. Interest and Purpose of Functional Analysis

The descriptive analysis of equipment involves cataloging its various components, often based on a predetermined schematic diagram, and clarifying their respective roles to deduce the operating principle and conditions of use.

In functional analysis, a technical object fulfills a specific function that meets a user's needs, which themselves are influenced by various factors (technical, economic, regulatory, sociological, etc.). The identified function is then decomposed into increasingly simple sub-functions, each of which is addressed through technical solutions. These functions are defined in terms of objectives without any preconceived solutions. The variety of possible technical solutions determines the range of equipment choices fulfilling the same overall function.

From a pedagogical standpoint, the functional approach aligns with an inductive methodology. It addresses the question of how to ensure minimal familiarity with technical solutions without resorting to an exhaustive survey of equipment.

The functional approach to system design employs inductive reasoning (causes/consequences), which requires defining objectives clearly before any diagnosis or solution research. Thus, it allows :

- Ensuring that a need is addressed and identifying degrees of freedom.
- Questioning existing solutions and broadening the scope of possibilities.
- Clearly delineating study areas and locally optimizing solutions without losing sight of the overall system.

The object of the functional approach can be a technological product or not, but also a service, process, project, organization, or enterprise. It is possible to conduct a functional study of housing, its heating installation, lighting design, ventilation system, refrigerator, or oven in its kitchen, as well as the potable water distribution system of a city, a municipal nursery, and even a social group or organization.

The general methodology of functional analysis applied to equipment is illustrated in Figure (1).

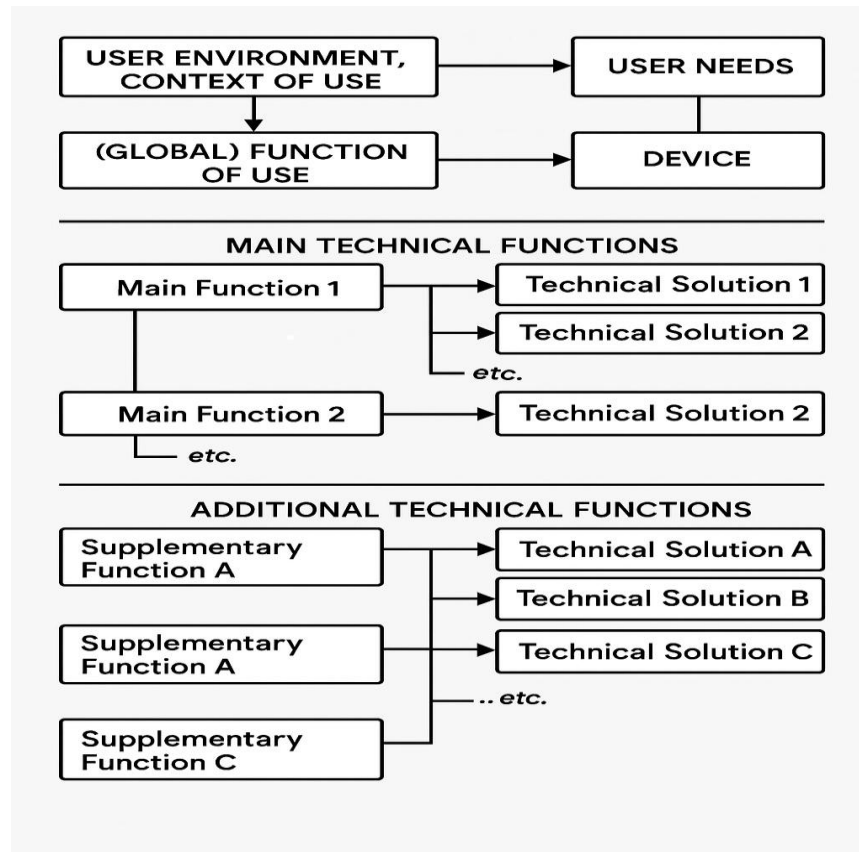


Figure (1): General Approach of Functional Analysis

Each technical object (device) or system under study fulfills a global function of use (or service function) to satisfy a specific user need. Within a given context, this need is shaped by constraints of various natures—material, technical, regulatory, economic, sociological—that must be clearly defined. For instance :

- **Material constraints:** energy supply, water supply, drainage, dimensions, layout design of the premises, etc.
- **Technical constraints:** performance, capacity, energy consumption, thermal insulation, lifespan, robustness, dimensions, noise, etc.
- **Economic constraints:** purchasing cost, operational costs, essential accessories, maintenance and servicing expenses, etc.
- **Professional constraints:** type and scale of production, production concepts and processes, working methods, types of products used, number of meals served, frequency of usage, compliance and certification standards, training and user or staff adaptability, etc.
- **Constraints related to hygiene, safety, and ergonomics:** compliance with current regulations, adherence to operational flow (forward-flow), ease of cleaning and maintenance, reduction and treatment of nuisances and pollutant emissions, thermal,

lighting, and acoustic comfort, working conditions, etc.

This overarching function is decomposed into main technical functions essential for achieving the expected service, and complementary (or secondary) technical functions which are not absolutely necessary but serve to enhance the device's performance, user comfort, ease of use, safety, and maintenance convenience.

Technical solutions represent the practical realization (components or parts of the device) of each technical function.

Each of these technical functions (primary or secondary) can vary in complexity. Hence, through a top-down analysis, these functions may be further decomposed into simpler elementary technical functions, which are then realized by straightforward technical solutions (precise and clearly identified components).

1.2. Principles of Functional Analysis

1.2.1. Concept of a System

A system can be defined in several ways :

- 1- A set of dynamically interacting elements organized according to a specific goal (the most general definition).
- 2- A modeling tool used to represent and analyze complexes of elements (material, abstract, or conceptual), characterized by their quantity and a network of nested relationships.
- 3- A finite and bounded set characterized by relationships linking it to its environment and other systems.

At any given moment, a system is characterized by its state (the set of values taken at a particular time by all elements that constitute the system) :

- 1- The variety of a system is defined as the set of all possible states of the system (e.g., washing machine cycles).
- 2- The state of a system is defined with respect to time.
- 3- In theory, the variety is independent of time (as in the case of fixed equipment). In practice, however, the variety may evolve if the system undergoes dynamic transformations.

1.2.2. Types of Functional Analysis

The types of functional analysis are :

1.2.2.1. Functional Analysis of the Need (External Functional Analysis)

This analysis identifies each service function (or main function), whether related to usage or esteem (Why was the object created?), and also highlights each constraint function (What constraints must the object meet?). Serving as a dialogue tool with the user, it enables the acquisition of essential data for the design of the system and the drafting of the functional specifications, which must be validated by the end-user or client.

1.2.2.2. Functional Analysis of the Product (Internal Functional Analysis)

Following the validation of needs, this analysis highlights each main and complementary technical function and enables the materialization of technical solution concepts.

It characterizes the internal functioning of the object or technical system and involves :

- Defining the system, its overall function, boundaries, and the inputs-outputs of materials exchanged with the environment.
- Identifying technical functions and decomposing them into sub-functions.
- Establishing and characterizing the relationships between elements within the studied object or technical system.

1.2.3. Concept of Function :

1.2.3.1. Characteristics of Functions

According to the AFNOR NF X 50-151 standard, functional analysis is a methodological approach that involves identifying, organizing, characterizing, prioritizing, and/or valuing the product's functions (hardware, software, process, or service) as expected by the user.

A function is the action of a constitutive element of a system, expressed solely in terms of its intended purpose (by describing "what it does").

1.2.3.2. Different Types of Functions

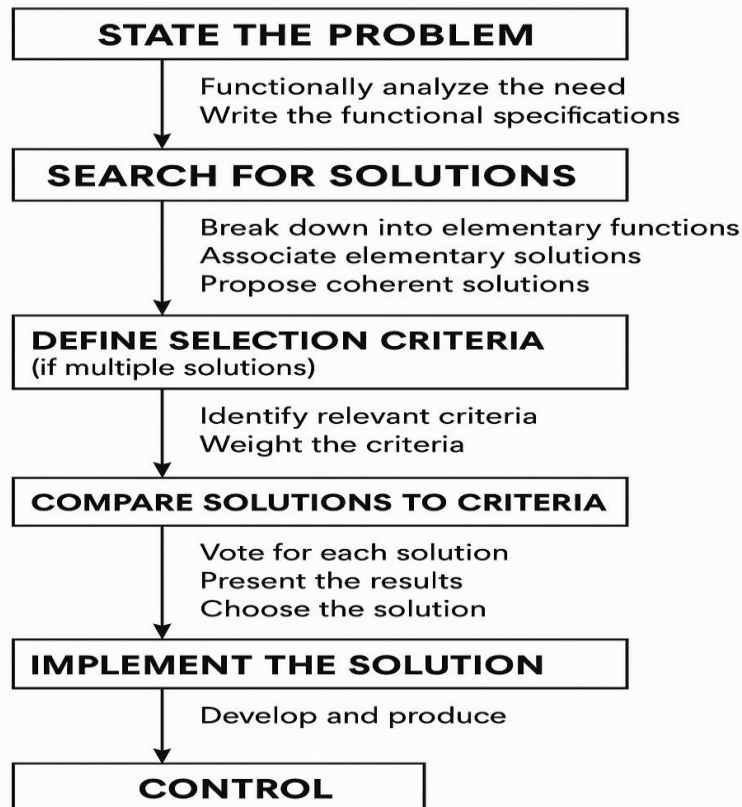
There are several types of functions, including :

- **Main Function (or Service Function):** a function expected from a product to meet a specific need or an element of the user's needs (material, physiological, psychological, sociocultural). This can be a usage function (service rendered) or an esteem function (conditions under which the service is rendered).
- **Technical Function:** an internal function of the product, essential for implementing solutions that fulfill service functions. This category includes :
- **Main or Elementary Technical Function:** enables fulfilling a usage function or rendering an expected service.

- **Complementary or Secondary Technical Function:** enables fulfilling an esteem function (e.g., safety, ergonomics, comfort, environmental considerations, legislative compliance, etc.).

1.3. Tools of Functional Analysis

1.3.1. Project Approach



1.3.2. "Bête à corne" Diagram: Identification of the Global Function

This tool, a key component of the APTE method, defines the need that the system aims to address. Frequently, project stakeholders tend to favor existing solutions without concretely analyzing the underlying need that justifies the project.

Before imposing a "how" or selecting a solution, it is essential to consult the user and/or requester to arrive at a structured solution, as a project holds meaning only if it satisfies the identified need.

Therefore, the need—and solely the need—must be clearly articulated from the outset of any project. The objective is to explicitly state the fundamental requirement that justifies the conception or redesign of a product.

1.3.3. The "Octopus" Diagram ("La Pieuvre")

This tool, derived from the APTE method, identifies the functions of a system or product by exploring the expected functions and their interrelationships through external functional

analysis (functional analysis of the need).

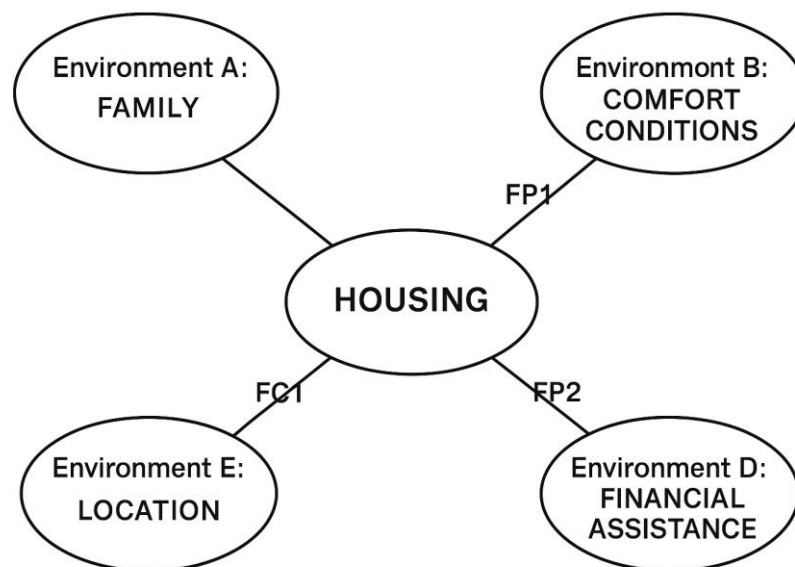
- **Main Functions:** These represent the reasons for which the object was created. For each phase of the product's lifecycle, the tool identifies interactions established by the object between two or more elements within its external environment. Subsequently, the objective of each interaction must be clearly expressed, thus defining each main function.

A main function is represented by two external elements (environments) and a verb.

- **Constraint Functions:** These represent the constraints that the object must satisfy. For each situation of usage, constraints imposed on the product by its external environment must be identified. This involves recognizing interactions between the object and a specific environmental element. The objective of these interactions defines a constraint function.

A constraint function is represented by one external element (environment) and a verb.

All interactions between functions and the object are graphically represented through the "octopus" diagram.:



Identifying functions is crucial in the lifecycle of a project. On one hand, functions reflect the description of the underlying need. On the other hand, they guide the selection of various scenarios for subsequent analysis.

1.3.4. Functional Table

The functional table allows characterization of main functions and constraints.

- **Evaluation Criteria:** Parameters selected to assess how effectively a function is fulfilled or a constraint is respected.
- **Evaluation Scale or Level:** Reference points established within the chosen scale to

evaluate a specific criterion for a function.

- **Accepted Tolerance:**

- ✓ **Flexibility:** Information about the possible variations or modulation permitted for a criterion.
- ✓ **Limits:** Criterion evaluation thresholds beyond or below which the need is no longer satisfied (minimum or maximum levels).

1.3.4 F.A.S.T. Diagram: From Global Function to Solution

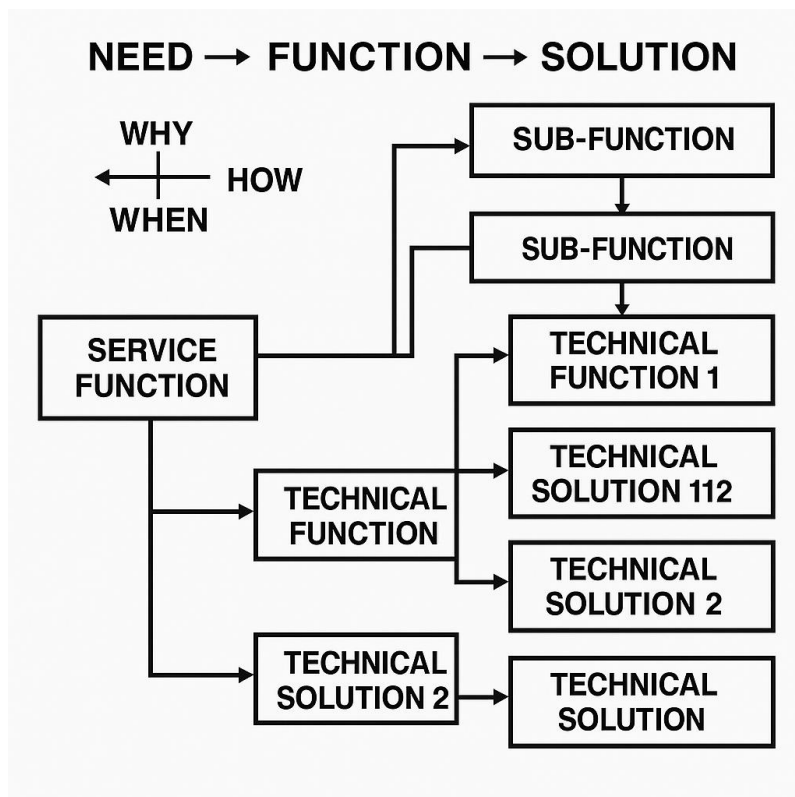
The Functional Analysis System Technique (F.A.S.T.) involves enumerating and clearly identifying functions, as previously illustrated with the dryer example.

This approach follows the pathway:

Global function → Functional decomposition → Technical solutions

It employs an interrogative technique (Why? How? When?) to effectively establish the link between NEEDS and SOLUTIONS.

Functional Diagram :



1.3.5 The S.A.D.T.: Top-down Analysis and Inter-functional Links

Structured Analysis Design Technique (S.A.D.T.) is a structured approach to analyzing and modeling systems, which aims to :

- **Model to understand**
- **Discipline the analysis process** (descending, grouping, hierarchical structuring)
- **Separate the "what" from the "how"**
- **Model reality** (through actigrams and datagrams)
- **Graphically formalize** the approach (clarity, conciseness, structured language)
- **Encourage teamwork** (author-reader iterative cycles)
- **Maintain documentation** (continuous updates and revisions)

This functional method originated from procedural languages. It emphasizes functions to be fulfilled and proposes a hierarchical, top-down, modular approach.

1.3.6 Functional Specifications Document (F.S.D.) – "Cahier des Charges Fonctionnel (CDCF)"

The Functional Specifications Document (F.S.D.) is a document through which the project owner explicitly communicates project requirements. These requirements should be articulated in terms of functions that the future user will perform or that the system must fulfill for the user.

Moreover, the F.S.D.:

- Encourages designers and providers to create and deliver the most efficient product.
- Simplifies the evaluation of proposals from different suppliers.
- Facilitates communication among stakeholders.

AFNOR Definition:

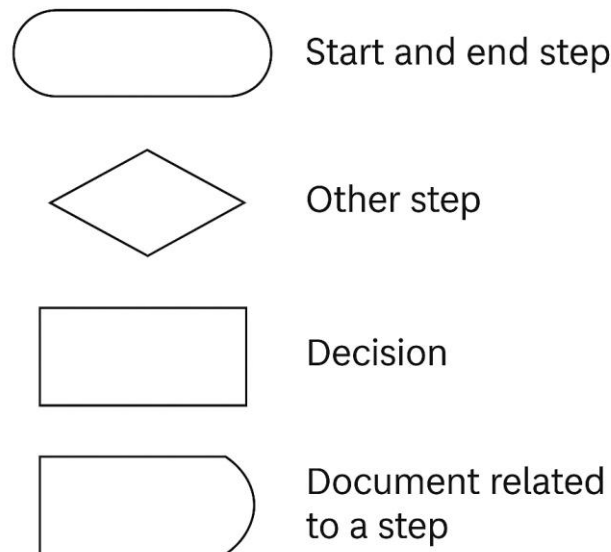
A document in which the requester expresses their need (or the need they are tasked with communicating) in terms of service functions and constraints. For each of these, assessment criteria and their levels must be clearly defined. Each specified level should include a degree of flexibility.

The F.S.D. must be drafted independently from potential solution concepts, thus preserving the broadest possible range of solutions. It should fully articulate user needs across various phases throughout the product's lifecycle.

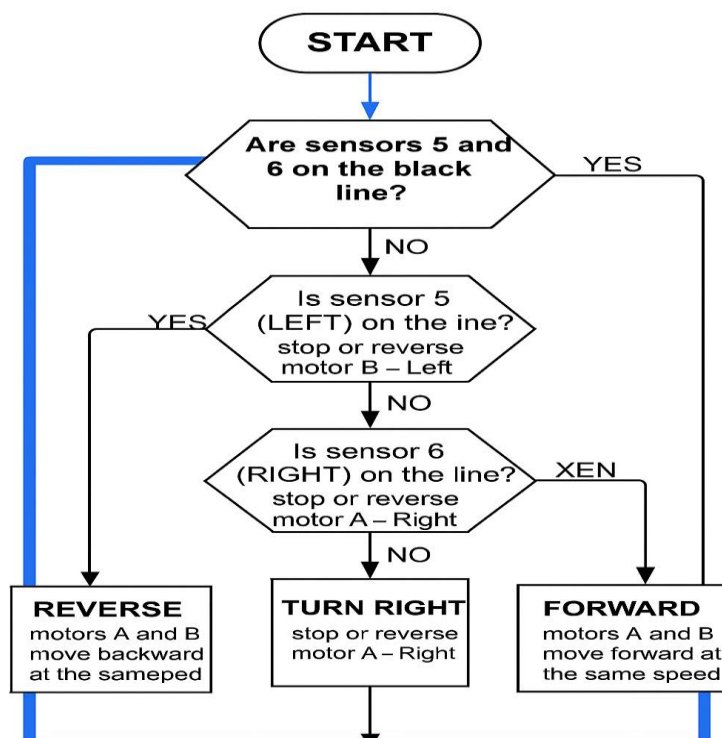
1.3.7 Flowchart

Sometimes defined as a tree structure of question-and-answer sequences, a flowchart is also known as an "ordinogram" or, somewhat incorrectly, as an "organigram." The objective of a flowchart is to represent the actions of a process whose sequence is chronological, by

breaking it down into individual steps. Thus, it becomes possible to visualize the progression of a process or a segment of a process. Consequently, a flowchart provides a simple linear representation of the sequence of steps constituting a given process. On the other hand, the duration required to create a flowchart is typically short. Since the description is fixed, the flowchart needs to be updated whenever the organization changes. Hence, the clarity and relevance of a flowchart should be validated by all stakeholders involved in the process.



Exemple de logigramme d'un robot suiveur de ligne



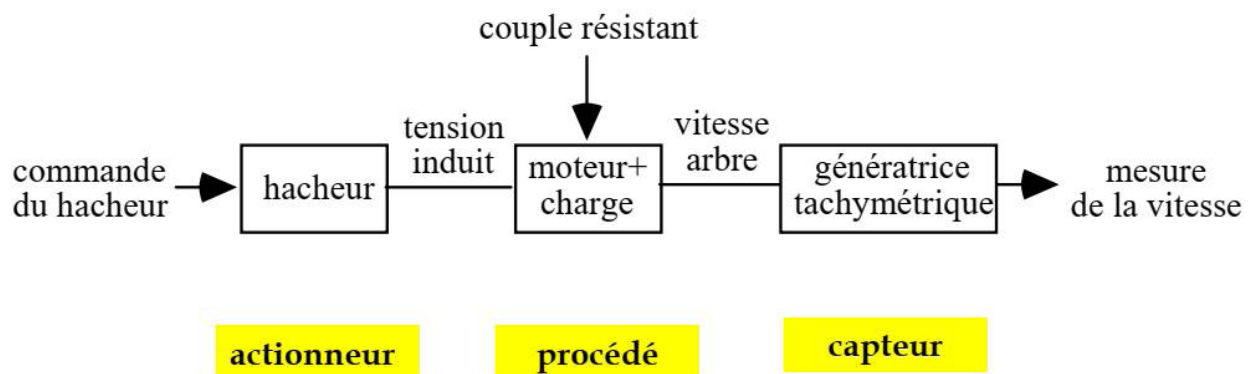
1.3.8 Functional Diagram

The functional diagram is used to represent a system by considering the various variables and elements that characterize it:

- Variables are represented by arrows.
- Elements are represented by rectangles (functional blocks); each functional block corresponds to a transfer function (TF) between an input variable and an output variable.

Example: Speed Variation

A more detailed functional diagram is shown below:



1.3.9 The PERT Tool

The P.E.R.T. (Program Evaluation and Review Technique) is an organizational method designed to arrange, in the form of a network, the tasks whose dependencies and chronological order collectively contribute to the achievement of a final product.

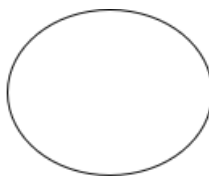
To establish a P.E.R.T. diagram, it is necessary to know in particular:

- The entirety of the project;
- The various tasks or operations that comprise it;
- The corresponding durations;
- The interdependencies between the different tasks.

Representation Symbols in P.E.R.T:

What is a milestone?

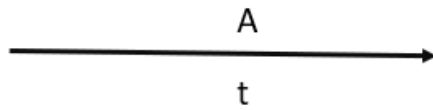
A milestone represents either the beginning or the end of a task. It has no duration. It is typically represented by a circle.



What is a task?

A task represents the progression of an operation over time. It is depicted as a vector, on which the action to be performed (e.g., Task A) and its duration (t) are indicated.

The length of the vector is not proportional to the time.



To Develop and Implement a PERT Network, Six Major Steps Can Be Distinguished

- Provide an exhaustive list of tasks to be executed.
- Evaluate the duration of each task and determine the resources required to accomplish them.
- Codify the tasks to facilitate the construction of the network (A, B, C, D, ...).

Tasks	Estimated Duration of Tasks (in days)
A. Study, design, and approval of plans	4
B. Site preparation	2
C. Ordering materials (wood, bricks, cement, roofing sheets)	1
D. Excavation for foundations	1
E. Ordering doors and windows	2
F. Delivery of materials	2
G. Pouring of foundations	2
H. Delivery of doors and windows	10
I. Construction of walls and roof	4
J. Installation of doors and windows	1

By answering the following questions:

- Which task(s) must be completed immediately before another can start?
- Which task should follow a given task?

We obtain the following table:

Immediate Preceding Task(s)	To perform this task...	Immediate Succeeding Task(s)
-	A	C, D, E
-	B	D
A	C	F
A, B	D	G
A	E	H
C	F	G
D, F	G	I
E	H	J
G	I	J
H, I	J	-

Graphical Representation of Tasks

- **Successive:**

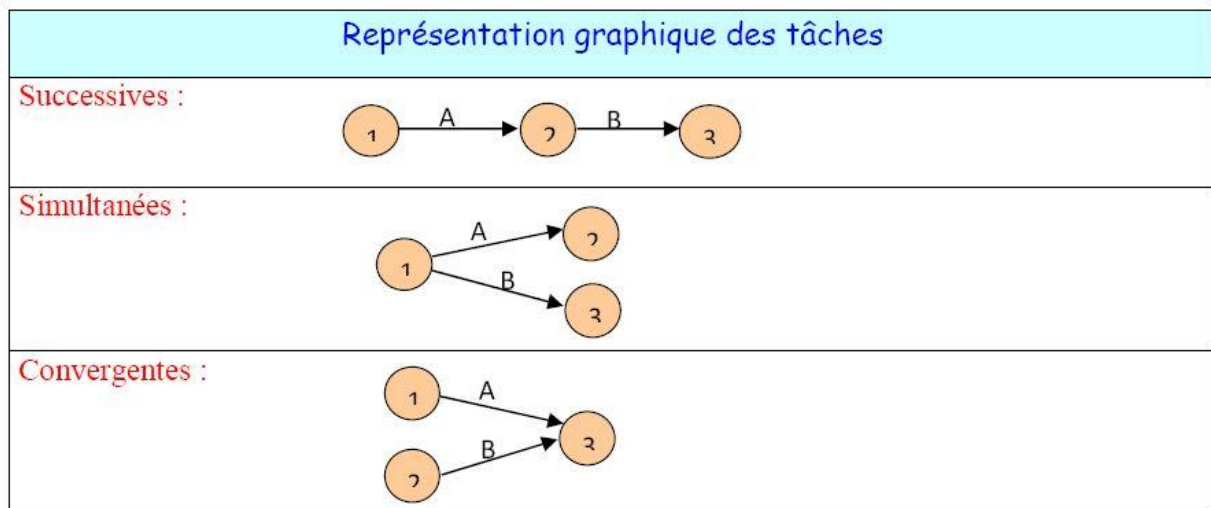
Task A must be completed before Task B starts, separated by intermediate milestones.

- **Simultaneous:**

Tasks A and B are carried out simultaneously after milestone 1, each leading to different outcomes.

- **Convergent:**

Tasks A and B must both be completed before reaching a common milestone.



Example 2

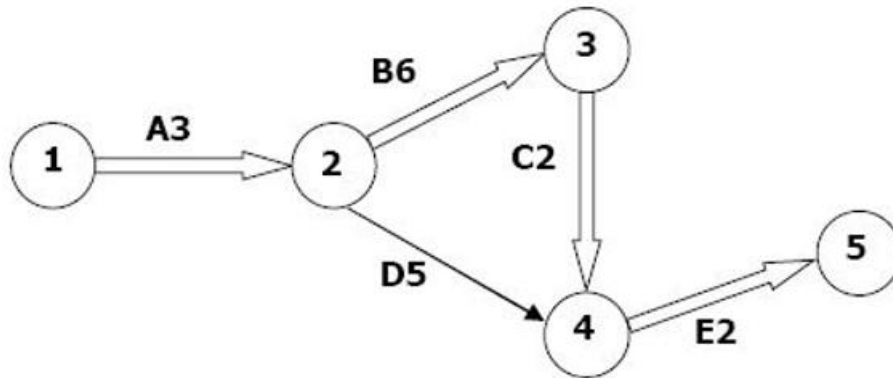
In a maintenance department, an intervention is planned that involves 5 tasks (A, B, C, D, and E). The methods department has estimated the time allocated to each task and established the following table:

Task	Preceding Task	Duration (h)
A	-	3
B	A	6
C	B	2
D	A	5
E	D, C	2

1. The first task to be performed is Task A.
2. Tasks B and C will start simultaneously after the completion of Task A.

3. Execute Task C, and finally Task E.

This schedule is represented by the following PERT network diagram:



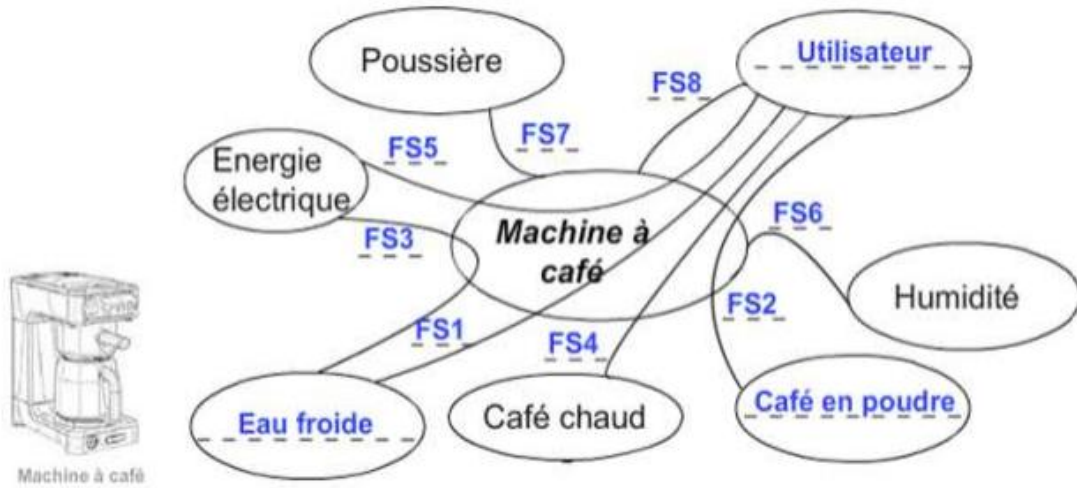
Standards

The standards associated with Functional Analysis in France include several active regulations related to functional analysis. Among them are:

- **NF X 50-100:** Functional Analysis – Fundamental Characteristics (1996).
- **NF X 50-151:** Value Analysis, Functional Analysis – Functional Expression of Needs and Functional Specification Sheet (1991).
- **FD X 50-101:** Functional Analysis – Functional Analysis as an Interdisciplinary Tool for Competitiveness (1995).
- **NF EN 1325-1:** Vocabulary for Value Management, Value Analysis, and Functional Analysis – Part 1: Value Analysis and Functional Analysis (1996).

Exercice N°01 :

- Tracer le diagramme Bête à cornes pour une machine à café
- Identifier les fonctions de service en distinguant entre fonction principale FP et fonction contrainte FC

**Exercice N°02 :**

- Tracer le diagramme pieuvre pour un scooter
- Tracer le diagramme bête a corne pour un sèche-main

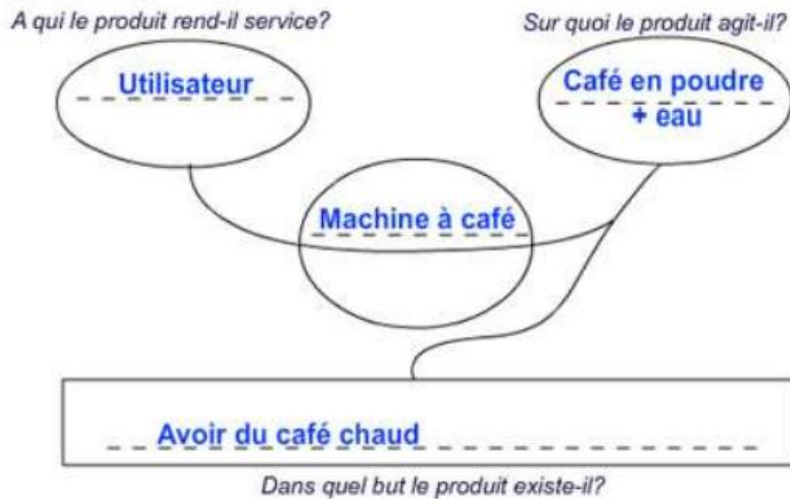


OUTILS D'ANALYSE FONCTIONNELLE – CORRIGE

TD1

Exercice 1 :

TAF : Tracer le diagramme Bête à cornes pour une machine à café



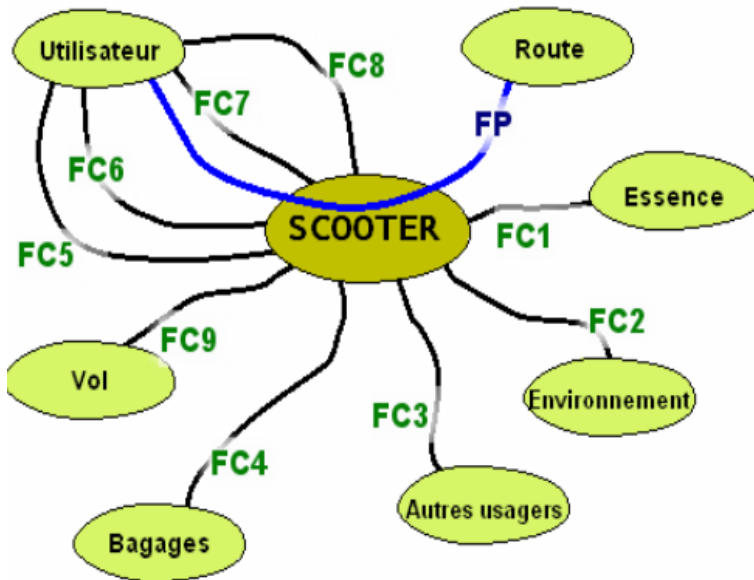
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Fonction de service pour la machine		Explication détaillée de la fonction
FS1 Doser l'eau	FP	L'utilisateur verse l'eau dans le réservoir de la machine à café qui est gradué, ce qui permet de doser la quantité d'eau utilisée
FS2 Doser le café en poudre	FP	A l'aide d'une cuillère de la machine à café l'utilisateur peut doser le café en poudre, à mettre dans le filtre posé en haut d'un grand verre
FS3 Chauffer l'eau	FP	La machine à café chauffe l'eau en petite quantité à l'aide d'une résistance électrique et le verse sur le café en poudre contenu dans le filtre. Après filtrage on obtient le café dans le grand verre.
FS4 Avoir du café chaud	FP	Le grand verre est posé sur une plaque chauffante, ce qui permet à l'utilisateur d'avoir tout le temps du café chaud.
FS5 Mettre la machine en marche	FP	En appuyant sur le bouton de mise en marche, l'utilisateur relie la machine avec le réseau électrique.
FS6 Résister à la corrosion dans un milieu humide	FC	La machine doit résister à la corrosion qui peut être provoquée par l'humidité ou l'eau.
FS7 Ne pas être endommagé par la poussière	FC	La machine à café doit résister à la poussière.
FS8 Plaire à l'utilisateur	FC	La machine à café aura une forme et une couleur pour plaire à l'utilisateur.

Exercice 2 :

SCOOTER

Diagramme Pieuvre:



Liste des Fonctions

Fonction principale:

FP : Déplacer l'utilisateur par rapport à la route, sans effort physique.

Fonctions contraintes:

- FC1 : Consommer peu d'essence
- FC2 : Respecter l'environnement
- FC3 : Respecter les autres usagers et se faire respecter d'eux
- FC4 : Transporter des bagages
- FC5 : Avoir un prix accessible pour l'utilisateur
- FC6 : Installer confortablement l'utilisateur
- FC7 : Sécuriser l'utilisateur
- FC8 : Plaire à l'utilisateur
- FC9 : Etre protégé contre le vol

Remarque : Nous avons distingué ici parmi les fonctions de service FS :

2 /

A qui rend-il service?



Sur quoi agit-il?



Dans quel but?

Énoncer « La Fonction Principale »
ou « La Fonction d'Usage »
À quoi sert cet Objet ?



Chapter 2. Analysis of Failure Causes

2.1. The Cause-and-Effect Diagram or Ishikawa Diagram

2.1.1. Definition

The cause-and-effect diagram, also known as the Ishikawa diagram, fishbone diagram, or the 5M method, is a structured analytical tool developed by Professor Kaoru Ishikawa in 1943. It aims to systematically identify and visualize the potential causes of a specific problem or defect (the effect) in order to implement appropriate corrective actions. This graphical representation organizes the contributing factors under five main categories — Manpower, Machine (Material), Material, Methods, and Environment (sometimes alternatively Maintenance, Management, or Marketing) — highlighting the causal relationships that lead to a given outcome. By mapping these interconnections, the diagram facilitates a comprehensive analysis, enabling effective problem-solving and decision-making.

2.1.2. Fields and Applications of the Cause-and-Effect Diagram

The cause-and-effect diagram, also known as the Ishikawa diagram, is primarily used for quality management and is often employed by quality circles to organize ideas generated during brainstorming sessions. Beyond quality control, it is widely applied in studies related to maintenance, reliability, and safety, particularly within the framework of Failure Modes, Effects, and Criticality Analysis (FMECA).

This tool serves multiple purposes: it helps to understand a phenomenon or process, such as troubleshooting procedures for equipment based on observed symptoms; it enables the analysis of a defect by tracing probable causes to identify the root cause; and it assists in identifying the full range of potential causes of a problem, thereby allowing for the selection of those causes that require deeper investigation to find appropriate solutions. Additionally, the cause-and-effect diagram can be used as a communication and training support tool, and it can act as a foundational knowledge base for problem-solving initiatives.

It is important to emphasize that the cause-and-effect diagram does not directly provide solutions; rather, it facilitates a structured and comprehensive definition of the problem, serving as a critical first step toward effective corrective actions.

2.1.3. Construction and General Form of the Cause-and-Effect Diagram

The Ishikawa diagram, also known as the cause-and-effect diagram or fishbone diagram, is graphically represented in the shape of a fish skeleton. Developed by Professor Kaoru Ishikawa, it is a method designed to classify and organize the potential causes of a problem according to the 5M principle: Manpower, Material, Methods, Machines, and Environment.

The construction of the diagram involves categorizing causes into five major groups:

- M1 – Materials: Includes raw materials, parts, assemblies, supplies, identification, storage, quality, and handling.
- M2 – Machines (Equipment): Encompasses causes linked to technical resources and utilized products, such as machines, tools, equipment, capacity, age, quantity, and maintenance.
- M3 – Manpower: Relates to human factors including direct and indirect labor, motivation, training, absenteeism, experience, competency issues, organization, and management.
- M4 – Environment: Covers the physical environment such as lighting, noise, workspace layout, relationships, temperature, climate, market conditions, and legislation.
- M5 – Methods: Involves instructions, manuals, procedures, and operating methods.

The general form of the diagram illustrates these categories branching out toward a central axis that leads to the identified problem (effect). This structured visualization not only helps in comprehensively listing all potential causes but also supports analytical thinking by emphasizing the relationships between causes and their resulting effects. It should be noted that while the Ishikawa diagram helps to systematically define the problem, it does not directly provide solutions; rather, it prepares the groundwork for subsequent problem-solving and decision-making activities.

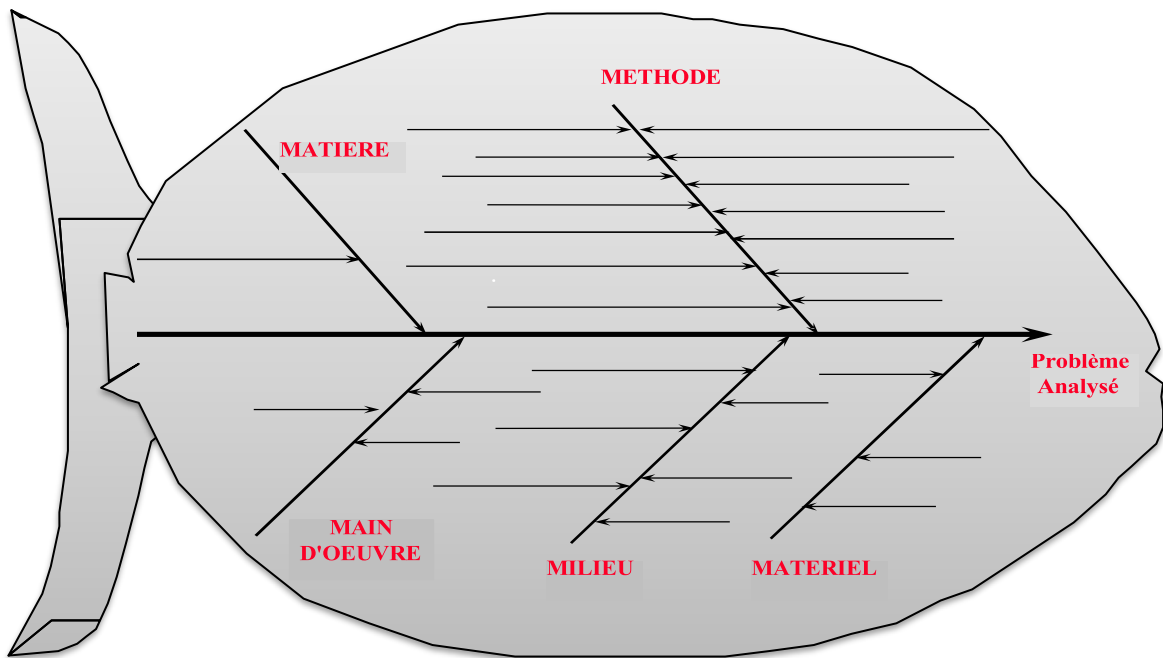


Fig.2.1. Ishikawa Diagram

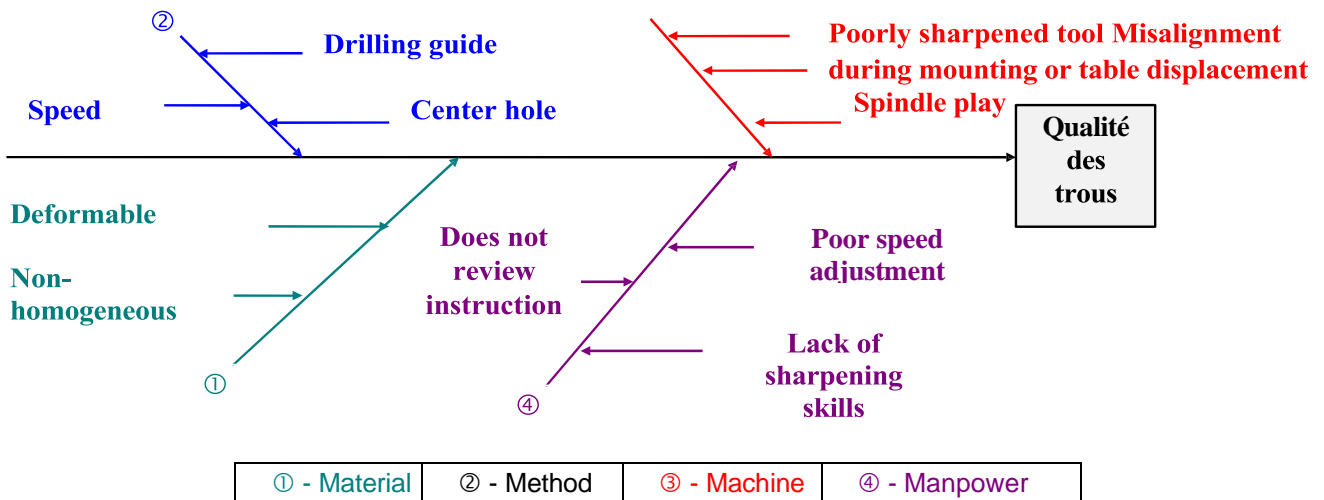
2.1.4. Methodology for Constructing the Ishikawa Diagram

- 1- **Define the Effect :** The effect must be formulated in simple terms, understood and accepted by all participants: what needs to be improved, changed, or modified? What is the expected outcome? The desired transformation should be measurable in order to objectively assess any modification. The effect should remain visible throughout the process to ensure the analysis stays focused.
- 2- **Identify the Causes :** This is the brainstorming phase. It is important to record all ideas without classifying or filtering them. Every idea should be noted visibly and kept on display during the entire session.
- 3- **Highlight Key Words :** For each statement made, the speaker should emphasize one or more key words. This often sparks new ideas, which should be added immediately and processed later.
- 4- **Categorize into Main Families :** To facilitate the idea search, the 5M method is commonly used. It directs the brainstorming toward five domains from which most causes typically originate. Alternatively, any other organization better suited to the specific problem may be employed:
 - **Machines:** Refers to all investments, equipment, facilities, and major tools.
 - **Manpower:** Refers to all personnel involved.
 - **Methods:** Includes work sequences, user manuals, instructions, written or unwritten procedures.

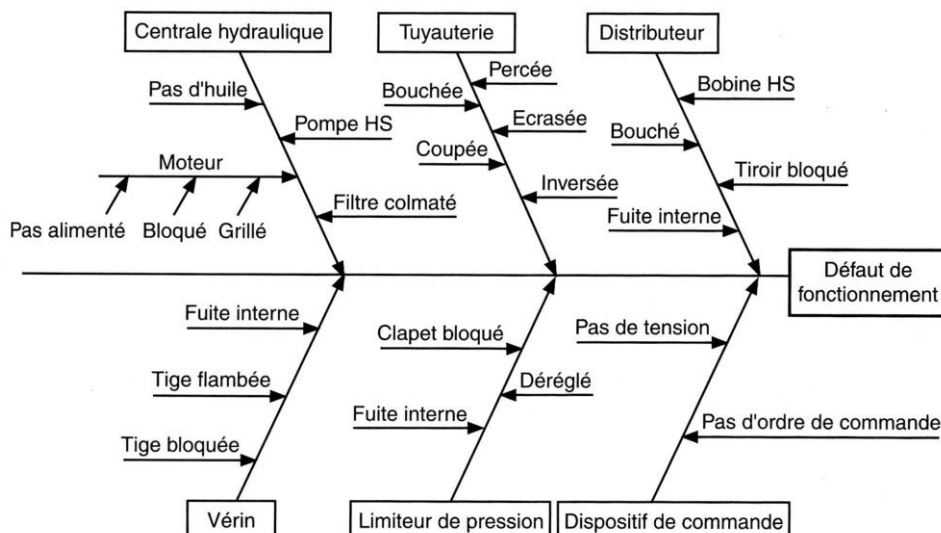
- **Materials:** Covers all consumables (raw materials, fluids, energy).
 - **Environment:** Refers to the physical and human environment, including working conditions, ergonomics, relationships, customers, and supplier-related issues.
- 5- Draw the Diagram :** The diagram is constructed by systematically placing the recorded ideas. Only key words are indicated along the arrows.
 - 6- Select Key Causes :** Begin the analysis by identifying the families (from Machines to Environment) that appear to be the most significant contributors to the effect.
 - 7- Define the Objective :** The objective must be clearly expressed in terms of the target value of improvement and the timeframe allowed to verify the progress.
 - 8- Determine the Means :** Choose the appropriate measurement methods, tests, and procedures needed for validation.
 - 9- Compare with Previous Results :** At this stage, it is crucial to verify whether the desired effect has been achieved. If not, the next group of causes is addressed until the desired improvement is obtained.

Example 1

When using a column drill, poor-quality holes are obtained.



Example 2



2.2. Pareto Histogram and ABC Analysis

The Pareto diagram is a valuable tool used to establish the distribution of failure causes across an entire system — such as a lifting mechanism — by analyzing the frequency of interventions and defining action priorities. The histogram is constructed as follows:

- The x-axis (abscissa) represents the causes of failures.
- The y-axis (ordinate) represents the frequency of defect occurrences.

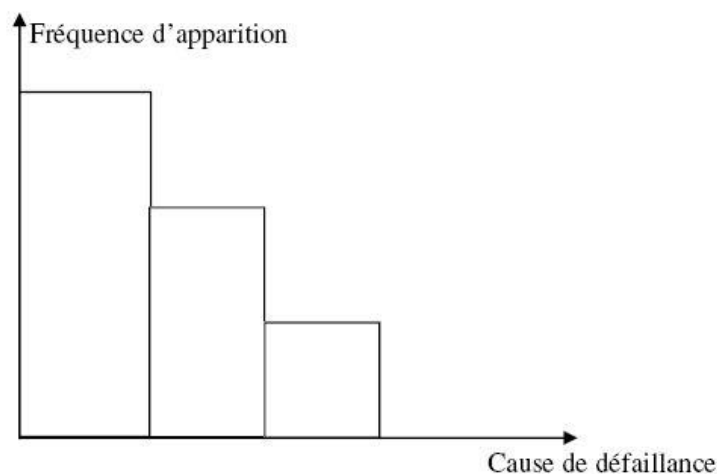
This approach allows for addressing defects in order of importance, targeting the most critical issues first.

2.2.1. Purpose of the Method

This analysis prevents organizations from being overwhelmed by minor tasks of little importance compared to the overall volume of work. The ultimate objective is to optimize actions, maximize resource efficiency, and enhance profitability.

The maintenance department can exploit this methodology further by:

- Creating a table that lists the subassemblies, the number of failures (N), the downtime per subassembly (Nt), and the average downtime (t).
- Developing bar charts for N, Nt, and t to determine maintenance intervention priorities.
- Using the N chart to guide improvements in reliability.
- Using the Nt chart as an indicator of system availability, as it reflects the downtime impact per subassembly.
- Using the t chart to improve maintainability, focusing on reducing repair times and enhancing the system's readiness for maintenance.



Overall Analytical Approach: The process involves fully understanding the situation,

evaluating the activity over a specific time interval, analyzing data as soon as they become available, and extracting clear indications for corrective actions and strategic recommendations.

2.2.2. ABC Method

Among the many concerns faced by a maintenance manager, it is essential to decide which failures should be addressed and/or improved first. To do so, it is necessary to identify the most critical failures, where resolution or improvement would yield the highest return, particularly in terms of downtime costs.

The challenge lies in the fact that what is "important" and what is "less important" is not always clearly distinguishable.

The ABC method offers a solution. It provides a structured approach to highlight the most critical elements of a problem, facilitating prioritization and decision-making. Events (such as failures) are ranked in descending order based on their associated costs (downtime, financial cost, number of occurrences, etc.), each event corresponding to a specific entity. A graph is then created showing the cumulative percentages of costs against the cumulative percentages of failure types.

The resulting diagram typically reveals three distinct zones:

- **Zone A:** 20% of failures account for 80% of the total costs.
- **Zone B:** The next 30% of failures account for an additional 15% of costs.
- **Zone C:** The remaining 50% of failures contribute only 5% of the overall cost.

It is evident that maintenance efforts should primarily focus on the failures located within Zone A.

In the field of maintenance, this method proves extremely useful for determining urgent tasks or the most cost-effective activities, such as:

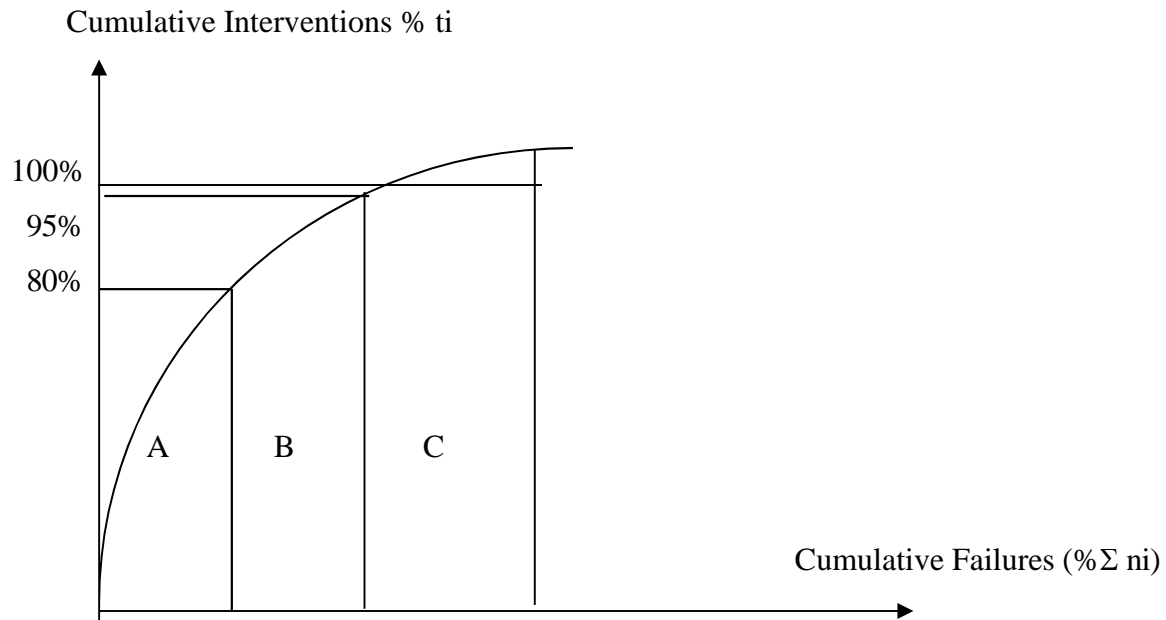
- Giving special attention to the preparation of interventions on the most frequent and/or costly failures (through documentation, operation sheets, contracts, scheduling, etc.).
- Investigating causes and identifying possible improvements for these critical failures.
- Organizing spare parts storage based on the frequency of part retrieval (number of parts and their location).
- Deciding on appropriate maintenance policies for certain equipment based on operating hours and maintenance costs.

Important Note:

While the ABC method aids in focusing attention on priority groups of elements, it does not

by itself resolve problems. Instead, it guides technicians toward the areas that warrant immediate investigation and action.

Theoretical Curve :



How to Construct the ABC Diagram

- 1 - Failures are ranked in descending order according to their duration, with the duration recorded alongside each failure
- 2 - Cumulative totals of times and failures are calculated
- 3 - The cumulative percentages of times and failures are determined
- 4 - A graph is created, where the x-axis (abscissa) represents the cumulative percentages of failures, and the y-axis (ordinate) represents the cumulative percentages of intervention times.

Exercice 01 :

Une machine comporte 10 sous-ensembles dont on a relevé l'historique des pannes.

L'entreprise, qui utilise cette machine, désire augmenter sa productivité en diminuant les pannes sérieuses. Pour cela elle demande au service de maintenance de définir des priorités sur les améliorations à apporter à cette machine. L'historique de la machine fournit le tableau suivant.

Sous-ensembles	A	B	C	D	E	F	G	H	I	J
Nombre de pannes	4	15	4	4	3	8	12	2	3	2

- 1- Tracer le diagramme de Pareto et la courbe ABC ?
- 2- Extraire les éléments les plus tombent en panne d'après la courbe ABC ?
- 3- Expliquer les trois zones de la courbe ABC?

Exercice 02 : En utilisant une perceuse a colonne .on obtient des trous de mauvaise qualité .construire de diagramme **de ISHIKAWA** à l'aide des causes suivant :

Vitesse , canon de perçage, ne relit pas les instruction , trous de centre , outil mal affûté, mauvaise réglage de vitesse, déplacement de montage ou table , , jeu de broche , déformable , non homogène , ne maitrise pas l'affûtage

SOLUTION TD 2

Exercice 01 :

A-Diagramme ABC :

Du tableau précédent, on tire le tableau des coûts et des pannes cumulées.

Sous-ensembles	Classement en coût (en h)	Cumul des coûts (en h)	% des coûts cumulés	Nombre de pannes	Cumul des pannes	% des pannes cumulées
D	57	57	31,3	4	4	7
E	56,5	113,5	62,4	3	7	12,3
A	26,5	140	76,9	4	11	19,3
G	17	157	87,2	12	23	40,3
B	11	168	92,3	15	38	66,7
I	9,5	177,5	97,5	3	41	71,9
H	1,5	179	98,3	2	43	75,4
C	1	180	98,9	4	47	82,4
F	1	181	99,4	8	55	96,5
J	1	182	100	2	57	100

Tableau 7: Tableau des coûts et des pannes cumulées (Application)

A partir du tableau ci-dessus, on construit le diagramme de Pareto (figure 5). Les cases grises nous donnent les limites des zones A, B et C. Il est donc évident qu'une amélioration de la fiabilité sur les sous-ensembles D, E et A peut procurer jusqu'à 76,9% de gain sur les pannes.

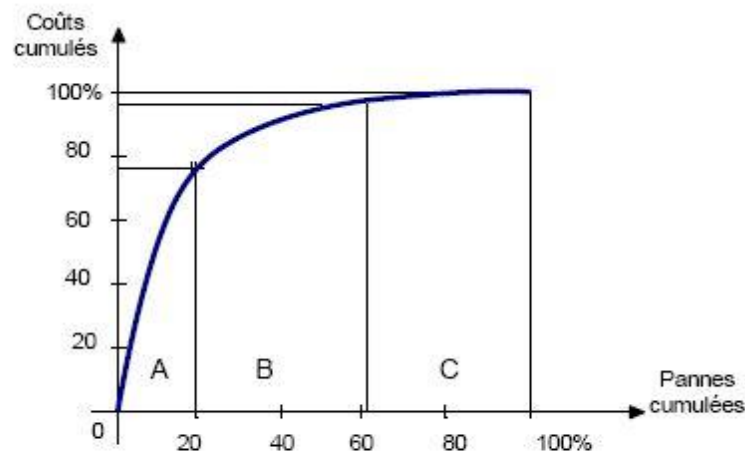
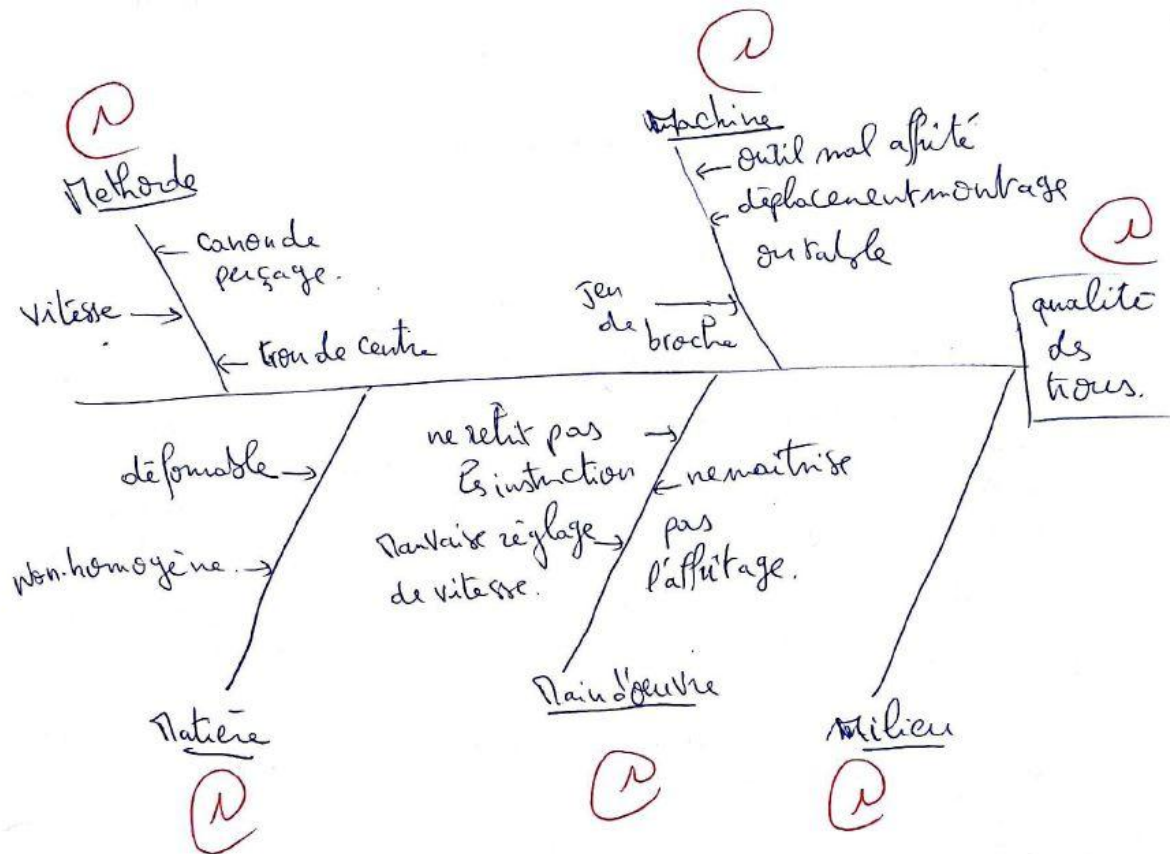


Figure 11: Diagramme de Pareto (Application)

Exercice 02 :



Chapter 3. Optimization and Securing of a Process

3.1. FMEA (Failure Modes, Effects, and Criticality Analysis)

3.1.1. Definition

Failure Modes, Effects, and Criticality Analysis (FMEA) is a preventive analysis method aimed at ensuring the operational safety of products and equipment. This preventive approach is based on the systematic identification and evaluation of potential error risks that may arise during all phases of a product's development. FMEA is a valuable tool that enables companies to validate the quality and reliability of a product throughout its construction process.

It serves the following purposes:

- It identifies the failure modes of components, evaluates their effects across all functions, and analyzes their causes.
- It assesses the impact or criticality of these failure modes on operational safety.
- During the design phase, it is combined with Functional Analysis to identify specific failure modes linked to each function or constraint of the components.
- When analyzing manufacturing procedures or production chains, it helps pinpoint operations that could result in products not meeting the design specifications, thereby limiting scrap and defects.

Techniques Used in Maintenance

- Applied to a multidisciplinary working group, FMEA is recommended for solving minor problems by identifying their causes and effects. It significantly contributes to product quality improvement and process optimization.

There are several types of FMEA, mainly divided into two categories:

- **Machine FMEA (Production Means FMEA):**

This focuses on identifying failures related to production equipment whose effects directly impact a company's productivity. It involves analyzing production assets to optimize maintenance activities.

- **Process FMEA:**

This identifies failures within the manufacturing processes whose effects directly affect the quality of the finished product (without considering failures of production machines themselves).

3.1.2. Historical Background

FMEA (Failure Modes and Effects Analysis) originated in the 1950s in the United States and Japan to enhance the reliability of high-technology products (such as armament, aeronautics, and space technology). Initially restricted to military applications, it entered Europe in 1970 through the nuclear industry (transitioning from military to civilian sectors).

The widespread adoption of FMEA was driven by its generalization within the automotive industry, starting in 1979 at Ford and in 1982 among French manufacturers. Subsequently, subcontractors followed suit. In compliance with standards such as QS 9000 (equivalent to ISO 9000 for the automotive sector), automotive suppliers were required to implement process quality planning (APQP), which included the use of FMEA and the development of control plans. The methodology later extended to the electronics industry, then to mechanical industries, and eventually incorporated broader considerations such as the safety of goods and people.

3.1.3. Approach of the FMEA Method

FMEA is a rigorous and exhaustive group work analysis technique, where each participant contributes their experience and expertise. Success depends on a thorough understanding of the system under analysis or access to reliable information sources. The method involves five main steps:

- Step 1: Prepare the study.
- Step 2: Conduct functional analysis.
- Step 3: Perform qualitative analysis of failures.
- Step 4: Evaluate criticality.
- Step 5: Define and implement a plan of corrective and preventive actions.

a. Step 1: Preparation of the Study

In the initial preparation phase, it is essential to validate the objective of the study: why is this study being conducted?

The objective will depend on the study context and may include:

- Improving product reliability,
- Enhancing the availability of production means,
- Improving the availability of the service provided.

The first task is to form the working group. FMEA relies on experience, requiring the collection of all relevant information held by various stakeholders, as well as fostering conclusions based on evidence rather than assumptions. Group work methodologies must be well-known and practiced to ensure optimal effectiveness, making them a crucial factor for success.

A – The Key Players in the Method

1. The Initiator (or Pilot):

The initiator is the person or department responsible for launching the study and overseeing it until completion. They define the subject, the criteria, and the objectives. They must remain independent of the design team to ensure unbiased judgment.

2. The Decision Maker:

This is the person within the company responsible for the study's results. They arbitrate discussions, establish consensus, allocate resources, and are responsible for decisions regarding costs, quality, and delivery times.

3. The Facilitator:

The facilitator guarantees the method's rigor and organizes the group's activities. They prepare meeting agendas, facilitate discussions, manage secretarial tasks, and monitor study progress. Often, this role is performed by an external participant or at least someone neutral to avoid internal bias.

4. The Working Group:

Typically composed of 2 to 5 responsible and competent individuals who are familiar with the system under study. They must contribute necessary technical information for the analysis (not just theoretical knowledge).

Depending on the study type, members may come from design, methods, production, maintenance, quality control, purchasing, or other related services.

B – Planning of Meetings

Since it is often difficult to bring together 5 to 8 participants from a given level (when they are available), the study is planned in phases — from **preparation** through to **action meetings** — following a rhythm of approximately half a day every 15 days.

C – Limitations of the Study

It is crucial to define and limit the scope and duration of the study. An overly broad scope could result in an overwhelming and inefficient exercise.

A study duration of **2 to 3 months** is generally considered reasonable.

D – Preparation of the FMEA File

During this phase, all necessary information is collected for the FMEA analysis, including:

- Organizational charts and job descriptions.
- Drawings, nomenclatures, manufacturing process plans.
- Calibration and verification plans (specifications, inspection sheets).
- Design and manufacturing constraints.
- Customer feedback (returns, product recalls, production rejects).
- Reliability assessments and test results.
- Statistical data: breakdown rates, fault histories.
- Probabilistic evaluations related to technology.
- Quality objectives.

E – Conclusion of Step 1: Summary Sheet

The summary sheet (often called the FMEA Synthesis Sheet) documents the study's progress over time. It consolidates all initial discussions and the ongoing findings of the study. It is prepared by the facilitator and completed with input from the decision-maker. Its goal is to formalize the initial elements of the FMEA and provide a reference document.

b. Step 2: Functional Analysis

The final objective of Step 2 is the creation of a comprehensive file on the system under study.

This file includes:

- A summary sheet of the current status of the FMEA study,
- The list of known functions to be analyzed,
- The identified functional interactions,
- The quality and reliability objectives (for design), or OEE (for production),
- The functional analysis,
- Historical data (such as from a FMEA computerized maintenance management system),
- The preventive maintenance plan,
- The product marketing and conditioning strategies.

c. Step 3: Qualitative Analysis of Failure Modes

Starting from the functional analysis, this step aims to:

- Identify potential failure modes (e.g., function loss, function degradation, random function failure).
- Identify the consequences of these failures (choices can be made based on the severity of

the consequences).

- Conduct cause analysis studies.

A – Listing Failure Modes

Examples include:

- Loss of function,
- Degradation of function,
- No function,
- Random or intermittent function loss.

B – Investigating Causes of Failure

The objective here is to identify the initial anomalies that could lead to a failure mode. It is crucial to maximize the identification of causes that could trigger the potential occurrence of a failure mode. The Ishikawa (fishbone) diagram is a useful tool to help with the cause investigation.

C – Studying Consequences

A consequence refers to the adverse effect that the user or customer might experience (e.g., dissatisfaction, defective quality, production shutdown). In the FMEA approach, the goal is to systematically list all potential consequences and, if possible, quantify the severity of their impact. Each failure mode leads to an effect that may be more or less severe depending on the function it impacts. It is preferable to clearly separate different effects linked to the same failure mode for greater precision.

D – Conclusion of Step 3: FMEA Grid

One way to gather the results of the working group is through the FMEA grid. It consolidates the analysis under a standardized format that typically includes:

- The item or subsystem name,
- The associated function,
- The failure mode,
- Its causes,
- Its consequences,
- Its likelihood of detection,
- And a severity rating.

The FMEA grid may also include a criticality index calculated based on the severity, occurrence, and detection likelihood of failures. The order of "failure mode, causes, effects, and non-detection" reflects the logic of the FMEA method. This structured classification, combined with criticality evaluation, helps prioritize different failures based on their risk level.

d. Step 4: Evaluation of Criticality

A – Concept of Criticality

Criticality allows the quantification of a risk level. In an FMEA study, criticality is evaluated based on the frequency of occurrence of the failure, its severity, and its probability of non-detection. It determines which corrective and preventive actions must be undertaken and sets the priority order for these actions. It is a key criterion for monitoring the predictive reliability of equipment.

The criticality rating enables a hierarchy of different failure modes to be established, helping to prioritize improvement actions by addressing the most critical risks first. A monitoring plan based on criticality allows decision-making based on objective data rather than intuition. An updated criticality assessment after implementing improvements provides a way to evaluate the effectiveness of the actions taken.

B – Criticality Scoring

Criticality is scored based on three key criteria:

- **F – Frequency of Occurrence of the Failure Cause:**

This measures the likelihood that a cause of failure appears during the use, manufacturing, or operation of a product.

Probabilities are often broken down into two levels:

P1 = Probability that a failure cause appears.

P2 = Probability that the failure cause, once it appears, leads to a detectable failure event.

- **G – Severity of the Failure Effects:**

Severity evaluates the importance of the failure's consequences on the function concerned or its impact on user satisfaction.

- **N – Non-Detection of the Failure:**

This criterion reflects the probability that a failure cause will go undetected by the production system or during product use, thus increasing the criticality score.

For each of these three criteria, companies typically define their own scoring scales, or they may use scales provided by external specialized organizations.

Expression of Criticality:

Criticality (C) is calculated using the formula:

$$C = G \times F \times N$$

e. Step 5: Define and Monitor a Preventive Action Plan

In this plan, preventive actions are identified and prioritized to lower the criticality coefficient. The aim is to reduce criticality by acting on one or more of its components (Frequency F, Severity G, or Non-detection N).

Corrective or preventive actions are then taken based on the severity of the risk. The primary goal is to reduce the occurrence of the causes of failures, improve detection methods, and lower the severity of their effects. All implemented actions must be recorded in the FMEA grid. After the actions are applied, a new evaluation of criticality is performed.

If the new criticality score remains unsatisfactory, additional preventive actions are defined.

3.2. The GANTT Method**3.2.1. Overview**

The Gantt method is a diagram-based technique, created around 1918, and still widely used today. Its principles can be applied even without presenting the full diagram. It involves determining the best possible way to schedule the various tasks of a project over a defined period, taking into account:

- The duration of each task,
- Precedence constraints between different tasks,
- Deadlines that must be met,
- Processing capacities (which may vary depending on authorized overtime or additional investments).

3.2.2. Method Presentation

To apply the Gantt method, the following steps must first be completed:

- Define the project to be carried out,
- Identify the various operations to be performed within the project,
- Specify the duration of each operation,
- Define the links and dependencies between these different operations.

Example :

We aim to organize the production at a workstation over one week.

Operations to perform:

Part Reference to Produce	Manufacturing Duration
A	3 hours
B	6 hours
C	4 hours
D	7 hours
E	5 hours

Links Between the Different Operations:

To meet customer deadlines, the following production order must be respected:

- Produce B and D after A,
- Produce C after B,
- Produce E after D.

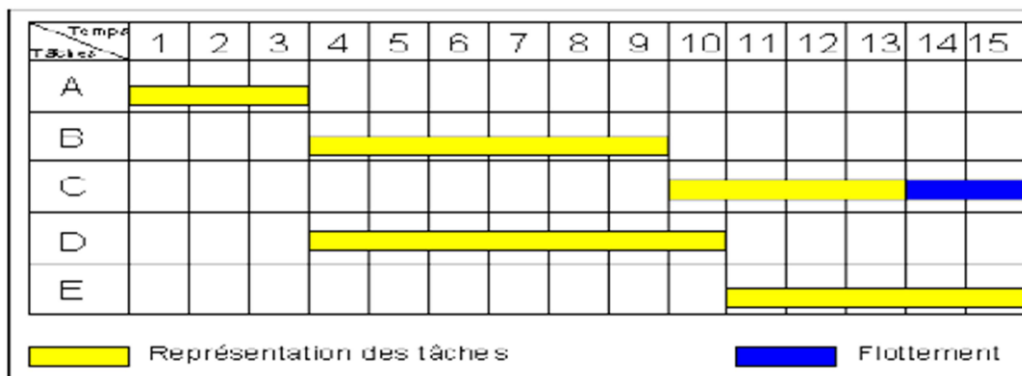
Gantt Chart Presentation:

The Gantt diagram is represented as a grid where:

- Each column corresponds to a unit of time,
- Each row corresponds to an operation to be performed.

A **horizontal bar** is defined for each task; the length of the bar represents the task's duration. The placement of the bar on the chart reflects the dependency links between the different tasks.

Thus, the Gantt chart corresponding to the previous example is shown below:



Classical Gantt Chart Representation :

The classical Gantt chart uses the following representation principle:

- Tasks without any predecessors are scheduled as early as possible.
- Then, tasks that depend on already scheduled tasks are represented accordingly.

This method can lead to stock accumulation and does not align with a just-in-time (JIT) system.

However, it can be adapted by starting tasks as late as possible.

Defining Task Links in a Project:

Several possibilities exist when defining the relationships between tasks:

- **Priority to producing items with the nearest delivery dates** (to meet deadlines),
- **Priority to confirmed orders** (first confirmed order executed first — although this may increase stock levels),
- **Priority to the task with the shortest duration** (to minimize changeover times),
- **Priority to the task with the smallest margin.**

Margin is calculated as:

Margin=Remaining time until delivery–Total completion time

- **Priority to the task with the lowest critical ratio**, where:

$$r = \frac{\text{Remaining time until delivery}}{\text{Sum of time for remaining operations}}$$

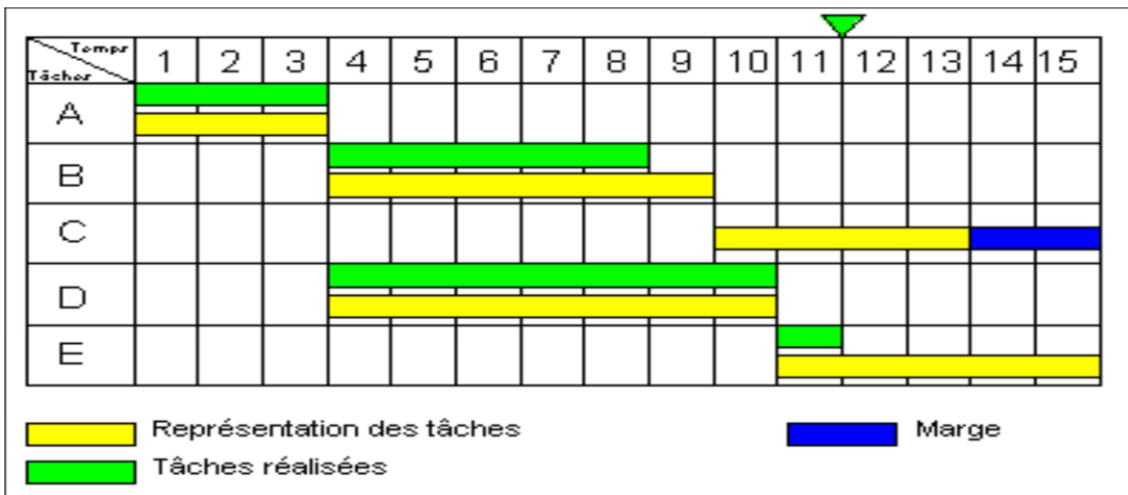
The last two criteria are especially useful for balancing both deadlines and production times.

3.2.3 Using the Gantt Chart

The Gantt chart allows:

- Visualizing the project's progress,
- Determining the project's total duration,
- Highlighting float times (slack) for certain tasks. (Float refers to the amount of delay that a task can absorb without affecting the overall project completion date.)

It also enables the representation of work progress directly on the chart, allowing for real-time monitoring of the project's advancement status.



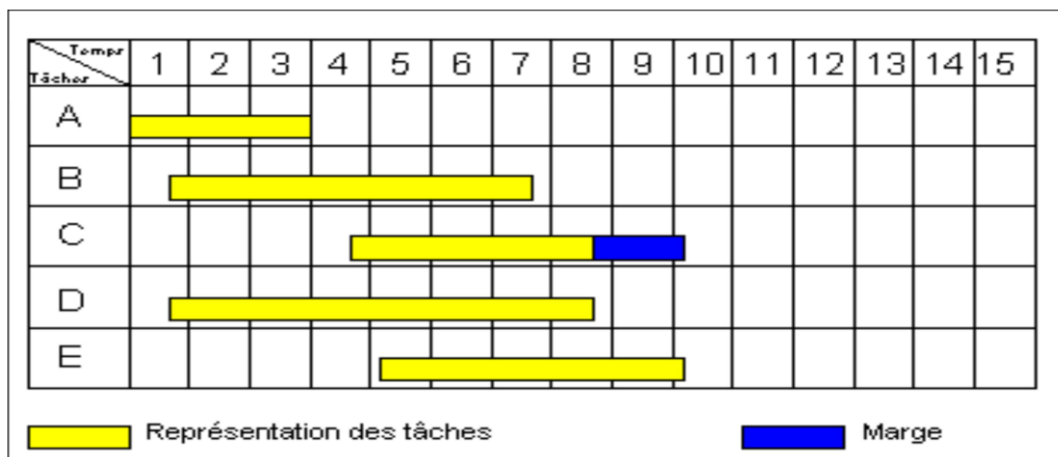
3.2.4 Optimization

It is possible to shorten the total manufacturing time when it is not necessary to wait for a preceding task to be fully completed before starting the next one. The calculation of the optimum timeline then depends on the availability of skilled personnel, equipment, and the costs incurred.

In the previous example, if we assume that:

- Tasks **B** and **D** can start once **20%** of task **A** is completed,
- And tasks **C** and **E** can start once **50%** of their preceding tasks (**B** and **D**) are completed,

then the corresponding Gantt chart would be as follows:



After optimization, approximately **five hours** are saved compared to the previous schedule. Today, many production management software tools use the Gantt method. The Gantt diagram remains a very simple tool to understand and use. However, its application is mainly limited to simple problems that do not involve a large number of tasks.

Gantt charts are, above all, a **visualization method**.

3.2.5. Usefulness of the Gantt Method

The Gantt method enables:

- Modeling the scheduling of tasks necessary for the completion of a project.
- Visualizing the project's progress and determining its total completion time.
- Highlighting the float times (slack) on certain tasks.
(*Float refers to the allowable delay a task can experience without affecting the overall project timeline.*)
- Representing the progress of work and knowing the real-time status of project advancement.
It also serves as an effective means of communication among different project stakeholders.

Thus, the Gantt diagram is extremely valuable for visualizing the project.

However, when the project involves a large number of tasks, the precedence relationships between tasks do not become easily apparent.

Today, Gantt charts are primarily used as a complementary control tool for monitoring project execution.

3.3. Kanban Method

Kanban is a Japanese word meaning "label" or "tag."

The Kanban is the label attached to a container.

It is generally presented as a small laminated or non-laminated cardboard rectangle.

A certain amount of information is specified on a Kanban.

This information may vary significantly from one company to another, but there are essential minimum elements typically found on all Kanbans:

- The reference of the manufactured part,
- The container's capacity,
- The address or reference of the upstream station and the address or reference of the downstream station.

A Kanban may be presented in the following way:

Part	Workstation	Container	Quantity
Engine Cylinder 55119	Deburring Station 125	Cu 212	220eces

3.3.1 Principle

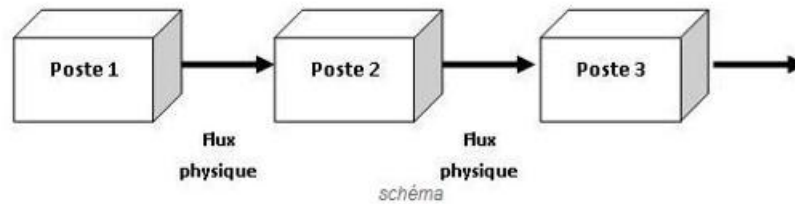
Let us suppose a production workshop where workstations are positioned sequentially, and where the production flow moves from left to right, passing through each station one after

another.

This can be represented as follows:

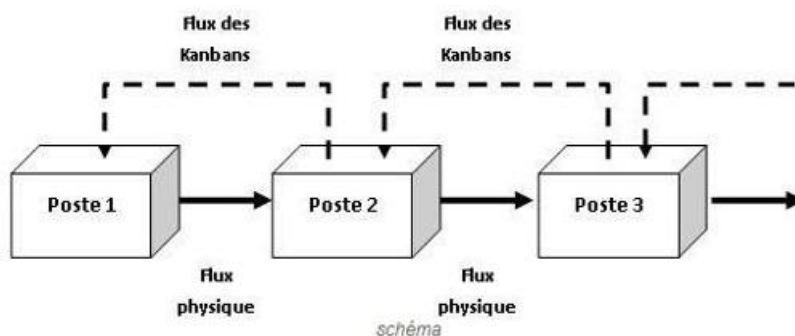
(Diagram 1: Physical Flow)

- **Post 1 → Post 2 → Post 3**
- Physical flow represents the movement of parts between workstations.



(Diagram 2: Physical and Kanban Flows)

- The Kanban method overlays an information flow on top of the physical flow:
 - **Kanban Flow:** Information circulates upstream to signal production needs.
 - **Physical Flow:** Products move downstream from one workstation to another.



Operation Between Two Consecutive Workstations

Between two consecutive workstations, the following can be observed:

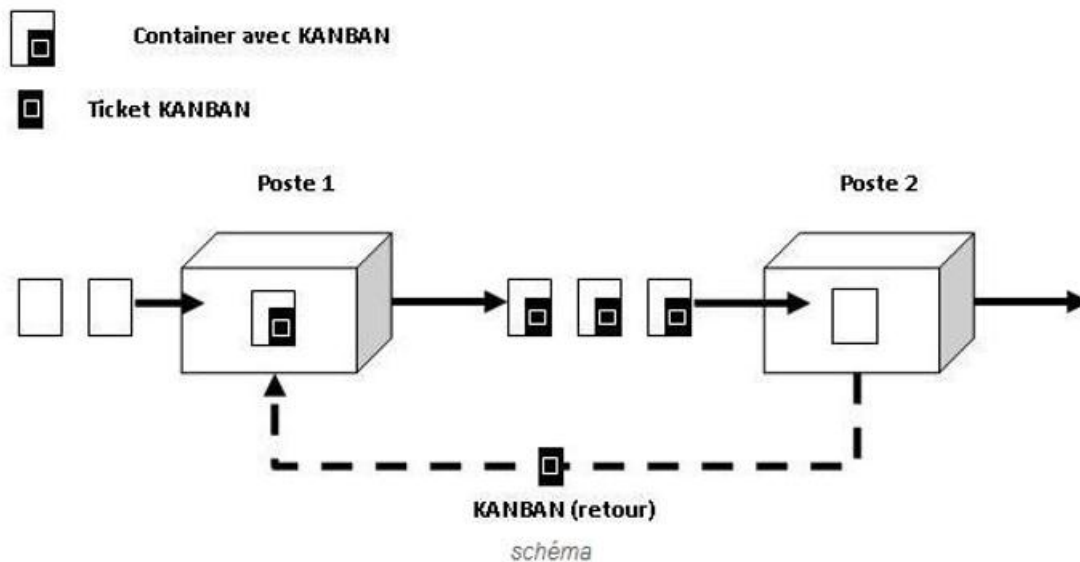
- **Workstation 1** machines parts and places them into a container. When the container is full, a **Kanban** label is attached to it, and the container is sent to **Workstation 2**.
- **Workstation 2** consumes the parts machined by Workstation 1. Each time Workstation 2 uses a container of parts, it detaches the **Kanban label** from the container and sends it back to **Workstation 1**. This label serves as a **production order** for Workstation 1 to manufacture a new container of parts.

- Between two workstations, there circulates a **finite number of Kanbans** (and therefore a finite number of containers).

Thus, Kanbans Are:

- Either attached to containers waiting in front of Workstation 2,
- Or registered on a Kanban scheduling board at Workstation 1, waiting for parts to be machined.

If there are no Kanbans on the scheduling board at Workstation 1 (meaning all Kanbans are attached to containers waiting in front of Workstation 2), then Workstation 1 does not produce anything.



Kanban Flow Between Workstations

This system is repeated between all workstations within the same workshop.

A specific Kanban circulates only between two specific workstations (thus, the Kanban will display both the upstream station address and the downstream station address between which it circulates).

The Kanban used in this case is called a Production Kanban.

Diagram explanation:

- **Container with Kanban:** A container labeled with a Kanban ticket indicating production requirements.
- **Kanban Ticket:** The card or tag representing the production instruction.
- Arrows indicate:

- **Physical flow:** Movement of the containers with parts from Post 1 to Post 2.
- **Kanban flow (return):** Return of the Kanban tickets from Post 2 back to Post 1 as production orders.

This system can only function properly if the two workstations are located close to each other, as there is then only one storage area for containers between **Post 1** and **Post 2**.

In cases where Post 1 and Post 2 are physically distant (such as in different workshops), an additional **transport operation** for the containers is necessary.

When **Post 2** uses a container of parts:

- It removes the **transfer Kanban** from the container.
- This Kanban is then placed on the **material handling schedule**.

The material handler then:

- Retrieves a container from the storage area at **Post 1**,
- Removes the **production Kanban** from the container and places it on **Post 1's Kanban scheduling board**,
- Attaches the **transfer Kanban** to the container,
- Then delivers the container to the storage area of **Post 2**.

Note:

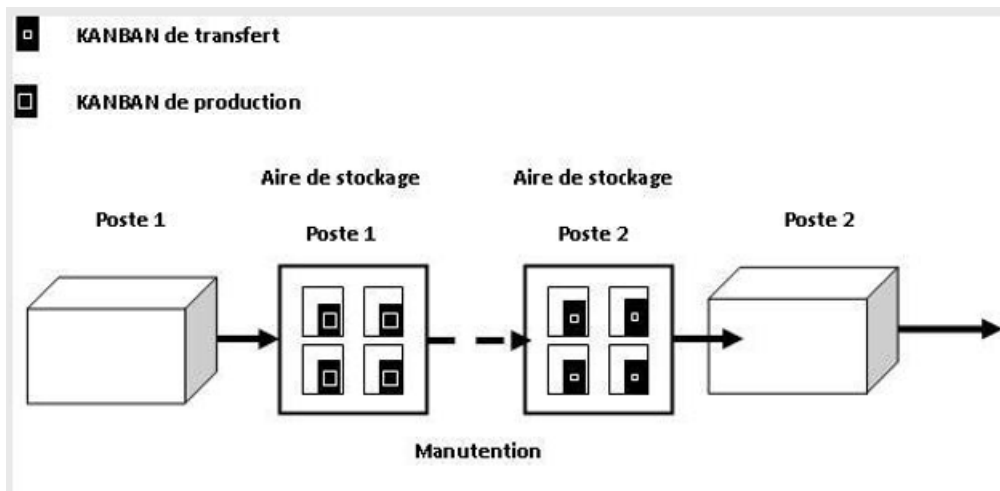
From the point of view of Kanban circulation, the same approach is ultimately applied, whether it concerns production operations or transfer operations.

Diagram explanation:

- **Transfer Kanban:** Represents the instruction to move containers between workstations.
- **Production Kanban:** Represents the production instruction to create parts.

The physical flow:

- From **Post 1** → to a **storage area at Post 1** → then transported by material handling → to a **storage area at Post 2** → and finally to **Post 2**.



When a workstation manufactures multiple types of parts, the Kanban scheduling board for that station will include a **different type of Kanban for each part type**. The operator must then **choose the correct part type to machine** based on the Kanban instructions.

Exercice 01 :

Un moteur thermique transforme l'énergie thermique en énergie mécanique pour créer un mouvement rotatif. L'**axe de rotation** transmet ce mouvement. Il peut s'user ou se casser, détectable grâce à des capteurs de vibration ou à des analyses d'huile. Si endommagé, il provoque des vibrations et réduit la puissance du moteur. Le **séparateur d'huile** empêche l'huile de mélanger aux gaz d'échappement pour améliorer la performance et réduire les émissions. Un séparateur obstrué, détecté par des tests de pression, peut causer des fuites d'huile et augmenter la pollution. Enfin, le **tube d'échappement** évacue les gaz brûlés, mais peut se corroder ou s'encrasser, détectable par inspection visuelle. Une défaillance ici limite le flux de gaz, ce qui réduit la performance du moteur et augmente sa consommation de carburant.

Complétez le tableau AMDEC suivant d'un moteur thermique

<i>Eléments</i>	<i>Fonction</i>	<i>Mode de défaillance</i>	<i>Effets</i>	<i>Mode de détection</i>	<i>Indice nominaux</i>			
Axe de rotation								
Séparateur d'huile								
Tube échappement								

Exercice 02 :

Soit la table d'antériorités représentant le déroulement des tâches d'un projet :

Tâche	A	B	C	D	E	F	G	H	I	J	K
Durée (J)	3	6	5	2	9	3	12	5	7	11	2
Antériorité	J	E	/	B	/	D-J	E-K	E-K	A-G	E	C-E

1-Dresser le diagramme de GANTT relatif à ce projet ?

2- Spécifier le(s) chemin (s) critique(s) en précisant les marges libres tâche ?

Exercice 03 :

Soit une consommation de 2400 pièces par jour (8 heures)

-Le délai pour un cycle est de 2 heures

-Le coefficient de sécurité est de 0.05

-La capacité d'un conteneur est de 50 pièces

A partir de l'ensemble de ces informations, calculez le nombre d'étiquettes Kanban nécessaires ?

Chapter 4. Management of the Initial Stages of an Analysis

4.1 KJ Diagram (Affinity Diagram)

The **KJ Diagram**, also known as the **Affinity Diagram**, is a tool used to organize a large number of ideas into logical groups based on their natural relationships. Developed by Jiro Kawakita, it is especially helpful when dealing with unstructured and complex data gathered from brainstorming or field observations.

Purpose:

- To sort and categorize diverse ideas.
- To identify common themes or problems.
- To facilitate team consensus and prioritization of issues.

Application: Often used during problem definition or root cause analysis in maintenance planning.

4.2 Variance Analysis

Variance Analysis is a quantitative technique used to compare planned performance with actual results. It helps in identifying deviations and their causes, allowing managers to take corrective actions early.

Types of Variance:

- Cost variance (planned vs. actual expenses)
- Time variance (scheduled vs. actual duration)
- Performance variance (expected vs. actual output)

Purpose:

- To monitor operational efficiency.
- To control budgets and resource usage.
- To improve forecasting and planning accuracy in maintenance operations.

4.3 Brainstorming

Brainstorming is a group creativity technique aimed at generating a wide range of ideas or solutions to a given problem. It encourages open and free thinking without immediate judgment or criticism.

Purpose:

- To foster innovative thinking among team members.
- To explore all possible causes of a problem or all potential solutions.
- To collect diverse insights in a short time.

Application: Commonly used in early stages of failure analysis or when selecting a maintenance strategy.

4.4 Quality Matrix

A **Quality Matrix** is a tool that maps the relationship between different elements such as customer needs and technical requirements. One common example is the **House of Quality** from the QFD (Quality Function Deployment) method.

Purpose:

- To prioritize technical actions based on customer requirements.
- To ensure that quality objectives are aligned with operational goals.
- To systematically evaluate the importance of various factors affecting quality and maintenance.

Application: Helps in designing maintenance procedures that directly support product or service quality.

4.5 Value Analysis

Value Analysis (VA) is a structured approach to analyzing the functions of a product or process to reduce cost without compromising performance or quality.

Purpose:

- To eliminate unnecessary costs.
- To improve product or process value by enhancing essential functions.
- To make maintenance strategies more efficient and cost-effective.

Application: Applied in optimizing maintenance schedules, spare parts management, and redesigning processes for reliability and economy.

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Abstract:

The focus of this content is on functional analysis, failure cause analysis, and process optimization in industrial systems, providing effective tools and strategies for maintenance and performance improvement. Functional analysis is used as a tool for understanding systems and analyzing their needs and products, with explanations of different types of analysis, such as the analysis of system needs and products. Various functional analysis tools are also introduced, such as Bête à Cornes diagram, Pieuvre diagram, Functional Table, F.A.S.T. diagram, which help in enhancing the understanding of functions and operations within industrial systems. Failure cause analysis is addressed with tools like the Ishikawa diagram (Cause-and-Effect) to identify the root causes of issues in systems, along with the Pareto diagram and ABC method, which are used to analyze and prioritize failures based on their impact. In process optimization, emphasis is placed on tools such as Failure Modes and Effects Analysis (FMEA) to assess potential failures and their impacts on the system. The Gantt method and Kanban method are explained as tools to improve productivity and organize time and material and information flows in industrial processes. Finally, tools for managing the initial stages of analysis are introduced, including the KJ diagram (Affinity diagram) and variance analysis to organize ideas and analyze data, alongside brainstorming and the House of Quality matrix for prioritizing and analyzing quality requirements. These tools aim to improve the efficiency of industrial systems and increase equipment lifespan, making them essential references in the field of maintenance and industrial analysis.

Keywords : Functional Analysis, Failure Cause Analysis, Process Optimization, Maintenance Strategy, FMEA (Failure Modes and Effects Analysis), Ishikawa Diagram, Pareto Diagram, ABC Method, Kanban Method, Gantt Chart, F.A.S.T. Diagram, Bête à Cornes Diagram, House of Quality, Quality Matrix, Root Cause Analysis, Affinity Diagram (KJ), Brainstorming, Industrial Systems, System Functions, Performance Improvement.

Résumé :

Le contenu se concentre sur l'analyse fonctionnelle, l'analyse des causes de défaillance et l'optimisation des processus dans les systèmes industriels, en offrant des outils et des stratégies efficaces pour la maintenance et l'amélioration des performances. L'analyse fonctionnelle est utilisée comme un outil pour comprendre les systèmes et analyser leurs besoins et produits, avec des explications sur les différents types d'analyse, tels que l'analyse des besoins du système et des produits. Divers outils d'analyse fonctionnelle sont également présentés, tels que le diagramme Bête à Cornes, le diagramme Pieuvre, le tableau fonctionnel, le diagramme F.A.S.T., qui aident à améliorer la compréhension des fonctions et des opérations dans les systèmes industriels. L'analyse des causes de défaillance est abordée avec des outils comme le diagramme d'Ishikawa (cause et effet) pour identifier les causes profondes des problèmes dans les systèmes, ainsi que le diagramme de Pareto et la méthode ABC, qui sont utilisés pour analyser et prioriser les défaillances en fonction de leur impact. Dans l'optimisation des processus, l'accent est mis sur des outils tels que l'analyse des modes de défaillance et des effets (FMEA) pour évaluer les défaillances potentielles et leurs impacts sur le système. La méthode de Gantt et la méthode Kanban sont expliquées comme des outils pour améliorer la productivité et organiser le temps ainsi que les flux matériels et d'information dans les processus industriels. Enfin, des outils pour la gestion des premières étapes de l'analyse sont présentés, y compris le diagramme KJ (diagramme de relation) et l'analyse des écarts pour organiser les idées et analyser les données, ainsi que le brainstorming et la matrice de la maison de la qualité pour prioriser et analyser les exigences de qualité. Ces

outils visent à améliorer l'efficacité des systèmes industriels et à augmenter la durée de vie des équipements, faisant d'eux des références essentielles dans le domaine de la maintenance et de l'analyse industrielle.

Mots-clés : Analyse fonctionnelle, Analyse des causes de défaillance, Optimisation des processus, Stratégie de maintenance, FMEA (Analyse des modes de défaillance et de leurs effets), Diagramme d'Ishikawa, Diagramme de Pareto, Méthode ABC, Méthode Kanban, Diagramme de Gantt, Diagramme F.A.S.T., Diagramme Bête à Cornes, Maison de la qualité, Matrice de qualité, Analyse des causes profondes, Diagramme de relation (KJ), Brainstorming, Systèmes industriels, Fonctions du système, Amélioration des performances.