Application of The Value Analysis To Redesign Facility Layout

Eyheraguibel Laurent* · Byung Ho Jeong** · Chan Gie Lee** · Sang Young Lee**

〈Abstract〉

This paper deals with an application of process value analysis method for a manufacturing process in order to redesign facility layout in a paper company. We have used the value analysis method which permits an overall and rigorous study of process by a functional approach. Firstly, customer's expectations for the future process are clearly and precisely expressed with specifications of the Functional Extern Analysis. The existing process is analyzed using various tool of the Functional Internal Analysis in the second part.

From the results of these analysis, we find out that the main problems of current facility are due to scheduling and facility layout. This paper is devoted to resolve the second problem. We suggest an ideal solution in order to have a reference solution. Nextly, We give realistic choices and the final solution for the facility layout.

Key Words : Process Value Analysis, Process Specifications, Functional Intern and Extern Analysis, Facility Layout

1. INTRODUCTION

The subject of this study was to apply the value analysis method to a manufacturing process in a paper company. The current layout of the company has several problems, primarily with overall plant layout which contributed to increase processing costs; inefficient material flow, disordered machines scheduling, bad working environment. Before the company invests some money in the reorganization of its manufacturing process, company managers were interested in studying the present process in order to detect and identify the real production problems in relation with overall layout.

The paper also suggests solutions in order to improve the overall production output. We use the procedure of the value analysis method. Indeed, the functional approach permits an overall, complete and rigorous study of the overall process and the overall layout. Moreover all the tools used in each part of this method (Functional Extern Analysis, Functional Intern Analysis, research of solution) are standardized tools specified in the French standard X50-150 permitting to develop a rigorous procedure [7].

Key steps of value analysis are the functional extern analysis and the functional intern analysis. The former determines the elements of the exterior environment for the process under consideration. We identify the relation of the system and one or more elements of its exterior environment using octopus graph[7]. The latter is devoted to study the existing process and to give a simple representations. Many tools are generally

* Mechanical Engineering in The Polytechnique de Sevenans
** Industrial Engineering in the Chonbuk National University

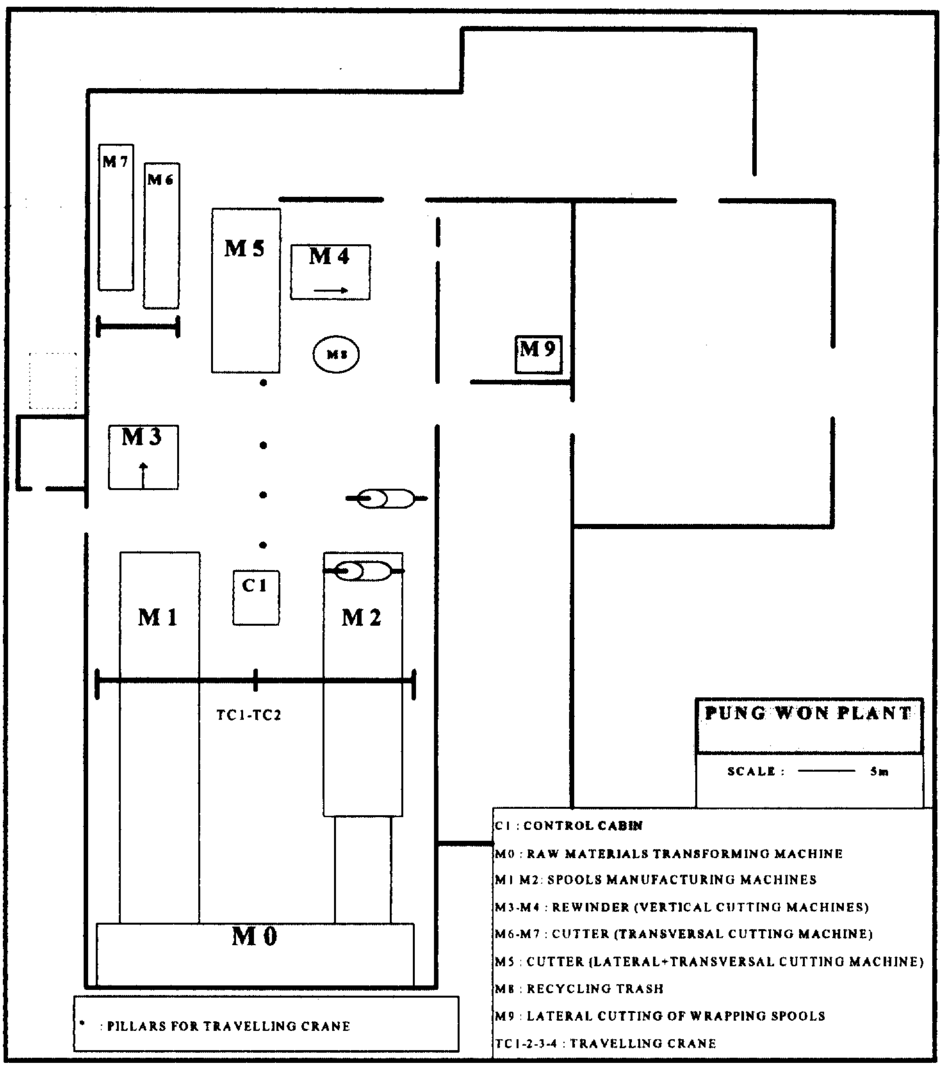
used for the process decomposition in this phase.

The section 2 describes some problems due to the current layout of the firm. It gives a general specification of the current layout. The application of the functional extern analysis and the functional intern analysis are described in section 3 and 4 respectively. Lastly, section 5 gives a resonable layout solution of the plant.

2. STATEMENT OF PROBLEM

2.1 Layout

The plant has a poor layout and the reasons are historical. Over the years, models and processes have changed. There was never enough time for rearrangement , so new machines or stores were located wherever there was room and not necessary



〈Figure 1〉 Layout of the present plant

in the most efficient locations. Some processes don't have enough space. The bad layout brings about many material handling problems and increases the possibility of accidents due to complex material flow. It is absolutely required to redesign layout of the plant. ⟨Figure 1⟩ shows an overview of current layout.

2.2 Material flow and material handling

In the production system, materials(or people) are moved through the entire production process, from the receipt of raw material to the delivery of finished products. For this factory, this movement of materials(or people) is too inefficient and must be reduced because there are many no-value-added activities due to very complex material flow and bacause these ones are very costly(energy, time,..). In addition material handling[8] is poor and too many operations rely upon manual manipulation. We can consider that all workers are potential carrier moving the needed materials from place to place. The result is a disorganized workers and material flow. For example, concerning treatment of scraps, all workers scoop and fetch paper scraps down the central recycling trash. The manual handling systems concerning transportation of the spool is dangerous for the workers, inefficient in processing time, bad for worker's health(lumbar problems) and bad for the quality of finished product(products are transported directly by rolling on the dirty ground).

2.3 Other problems of the process

Workers safety is one of important problems in the plant. Moreover, there is no protection or guard rails concerning all the machines which are very dangerous. Safety problems are numerous and directly in relation with the factory layout[9]. Bottleneck is also an important problem of the plant. There are too many work-in-process inventory in front of rewinder. Machines used in the process produce noise, heat, vibrations and fumes. All these factors may indeed slow down production and can have a major cause of low quality in addition to having a detrimental effect on efficiency[5,9].

The company's manager was interested in an improvement with realistic solutions to manufacturing process, material flow, and new layout in order to increase overall productivity.

3. THE FUNCTIONAL EXTERN ANALYSIS

It is firstly required to list each utilization step of process and to identify the relation of each process and one or several elements of his exterior utilization environment. ⟨Table 1⟩ shows the list of main processes. These processes are not chronological, and some of these utilization phases are repeated several times during the process cycle. It isn't a sequential description of process but the functional expression of process specifications (what will have to respond the future process) is required for each process.

⟨Table 1⟩ List of main processes

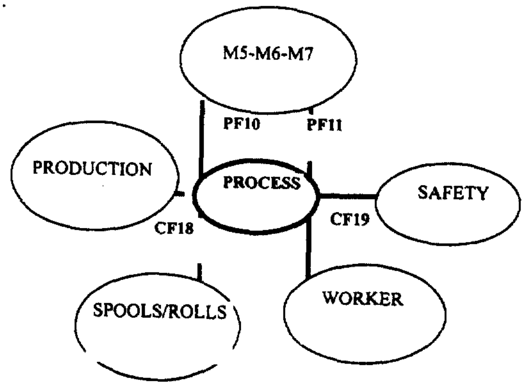
1-Spools manufacturing	8-Rolls transport to M6-M7
2-Matter stocking before transformation	9-Lateral cutting
3-Discards transport to M8	10-Inspection
4-Spools transport to M3-M4-M5	11-Packing
5-Vertical cutting	12-Lateral cutting of wrapping spools
6-Repairing if the paper is tore	13-Wrapping spools transport to M9
7-Rolls and sheets transport to store	14-Sheets transport to P1-P2-...-P9

PF10 : Permit to cut edgeways the spools or rolls with M5-M6-M7.

PF11 : Permit at the worker to adjust and regulate M5-M6-M7.

CF18 : Be synchronized with the production.

CF19 : Respect the workers safety.



PF10			CHARACTERISTICS		
M5-M6-M7 (CUTTER)			Lateral cutting machine		
Spools/Rolls			Spools from M1-M2 for M5 and Rolls from M3-M4 for M6-M7		
To cut	Criterion	Level criterion	Acceptation limit	Level flexibility	Exchange rate
	Cutting time for1 cycle (minute)	M5 : 180 M6-M7 : 240	/ /	+/-10% 50<time<420	/ /
	Number of roll for 1 cycle in relation with density	45 g/m^2 : 12 rolls 70 g/m^2 :9 rolls 100 g/m^2 : 5 rolls 120 g/m^2: 4 rolls 130 g/m^2 : 4 rolls 170 g/m^2 : 3 rolls	/ / / / /	+/- 1 %	/ / / / /
	Spools dimensions before cutting (mm)	M5 200<W<2430 M6 200<W<1000 M7 200<W<1000	R = 550 +/- 5%	/ / /	Depend of the customer
	Sheets dimensions after cutting (mm)	M5 200<W<2430 200<W<1500 M6 200<L<1500 200<W<1000 M7 200<L<1000 200<W<1000	/ / / / / / / /	/ / / / / / / /	Depend of The customer
	Utilization time by day of M5-M6-M7(min)	24 hours on 24 hours	/ /	/ /	Depend of the need
	Maximum capacity for cutting	600 g/m2	/ /	/ /	/ /

PF11			CHARACTERISTICS		
M5-M6-M7 (CUTTER)			Lateral cutting machine		
Worker			Experimented worker		
To adjust	Criterion	Level criterion	Acceptation limit	Level flexibility	Exchange rate
	Worker experience	5 years	/	/	/
	Set up time by cycle (minute)	M6-M7: 50	/ /	+/- 10% +/- 10%	/ /

〈Figure 2〉 Octopus graph and functional board for "transversal cutting"

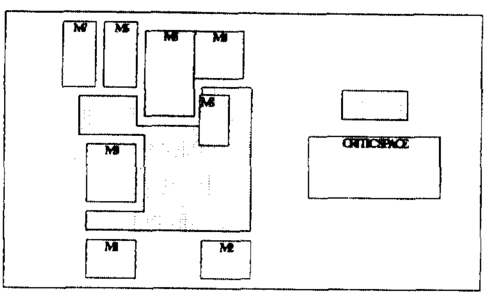
All these processes are absolutely required in order to produce the final products (sheets or roll paper). We identify all the elements of the exterior environment and relation to the corresponding stage, and give all the expectations of the elements (machine capacity, characteristic of products, production time, ...) with the octopus graph and the functional board. ⟨Figure 2⟩ shows the Octopus graph and functional board transversal cutting process. The figure shows that cutting machines (M5, M6, and M7) have two principal functions, cutting and adjustment of machine.

Concerning the criterion "cutting time per cycle", the level criterion corresponds to the standard time of each machine. The level flexibility represents the error tolerance accepted. For the criterion, cutting time of cutter M5 can vary in the interval of 180 minutes ±10%. The exchange rate expresses the factor which influence the level criterion : for example, the cutting time depends essentially on the number of rolls to be cut at once.

4. THE FUNCTIONAL INTERN ANALYSIS

4.1 Flow study

We study flow of all materials (goods, goods delayed, packing matter, human flow,...) in order to identify the bad flow (direction, distances). Moreover, we study also the schedule of each ones in order to detect the principal and permanent flow interactions. Finally, we give the location of the critical space inside the plant (see ⟨Figure 3⟩). This critical place is the location of all cross-roads of main material flow, of which frequency is very large. There are too many work-in-process inventory in this area.



⟨Figure 3⟩ location of the critical place

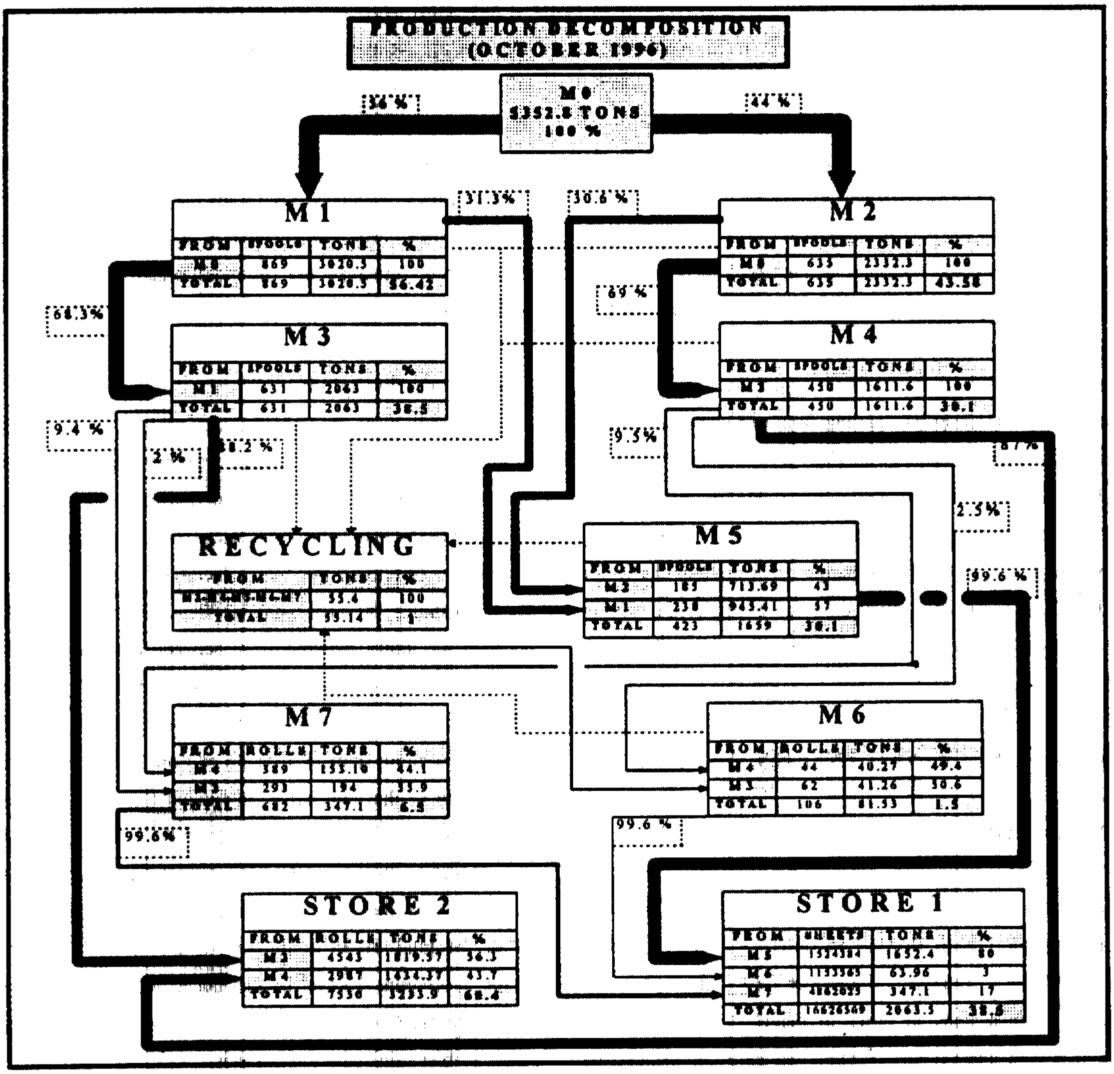
The complexity is imposed by the layout. This poor layout creates safety problems, increasing cost(energy, time), many converse flow. The layout solution will have to avoid flow interference, minimize the distances required for each flow, and improve the working environment and workers safety.

4.2 Production graph

Production graph is used to quantify flow amount the intention of decomposing the production for each machine and to understand relation between each ones. Moreover this graph permits to determine the future facilities layout according to the importance of each material flow. Production graph in ⟨Figure 4⟩ shows material flow between each two machines or processes. We analyse the importance of each flow according to the quantity (weight) of paper which is used for its corresponding stage. The width of flow line represents what percentage of the total paper production flows on the line. In other words, it describes the importance of flow on the line. For example, machine M6 plays a low part in the process: only 1.5 % of the total production is used corresponding at 3 % of the total sheets production (board store 1). The same graph as ⟨Figure 4⟩ can be reproduced with the real location of all the machinery in order to analyse and identify the main (and problematic) flow cross-roads.

4.3 SADT(System Analysis Design Technique) modelling

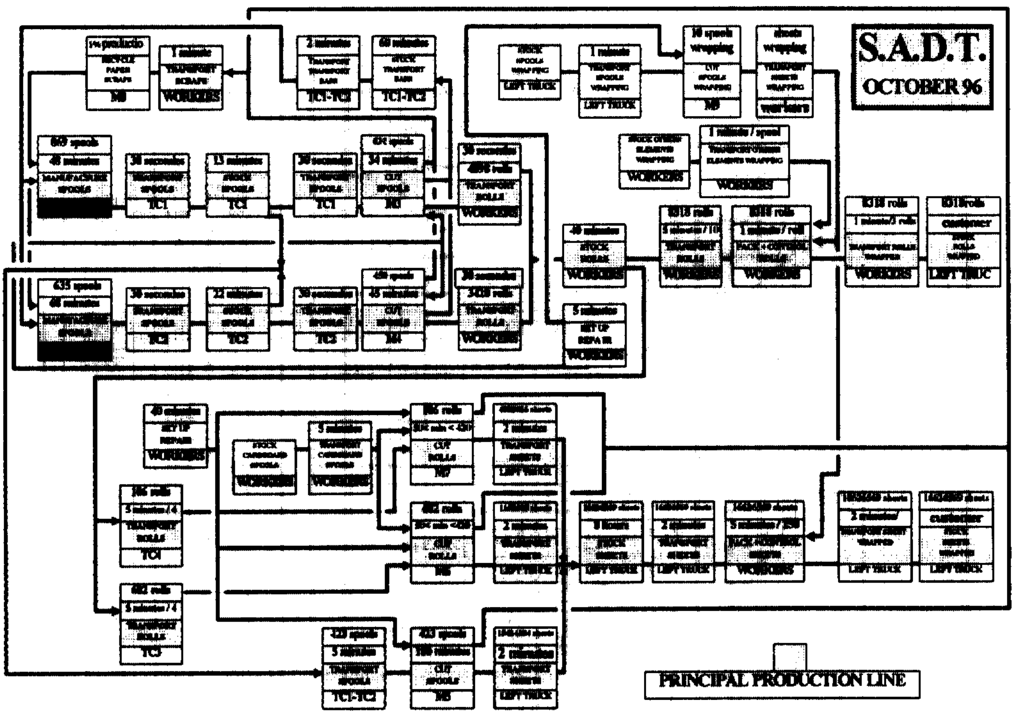
SADT modelling permits the decomposition of process with *actigrams*. Actigram is identified by a box representative of one stage of process completed by control data (rate, production) and the mechanism used for this corresponding action. SADT modelling is in fact a complement of the FAST (Function Analysis System Technique) diagram but permitting a more general view of process including a structural and functional decomposition and the behavior process in the time.



〈Figure 4〉 Production graph

Consequently, we can identify bottlenecks between each stage and analyse the relation between each machine scheduling.

We can give an example for the SADT analysis. The graph in 〈Figure 5〉 points out that there is no bottleneck between M1(M2) and M3(M4) because cutting time per cycle in M3 (M4) is always smaller than manufacturing time in M1(M2)-including transport and set up time. In the SADT we consider a stocking time of 13 minutes before M3(M4) utilization because the production is always bring forward of one spool (the synchronization can't be perfect !). However SADT decomposition shows us that there is bottleneck between M3 (M4) and M6(M7). Indeed the average time for cutting one spool is about 34 minutes for the rewinder M3 and 45 minutes for the rewinder M4. Moreover, cutting time in M6(M7) is very different according to paper density (50 minutes for 3 rolls of 130 g/m^2 but 420 minutes for 12 rolls of 45 g/m^2). It is obvious that if the operation is repeated several time one after the other, we should have much stock area for many delayed products.



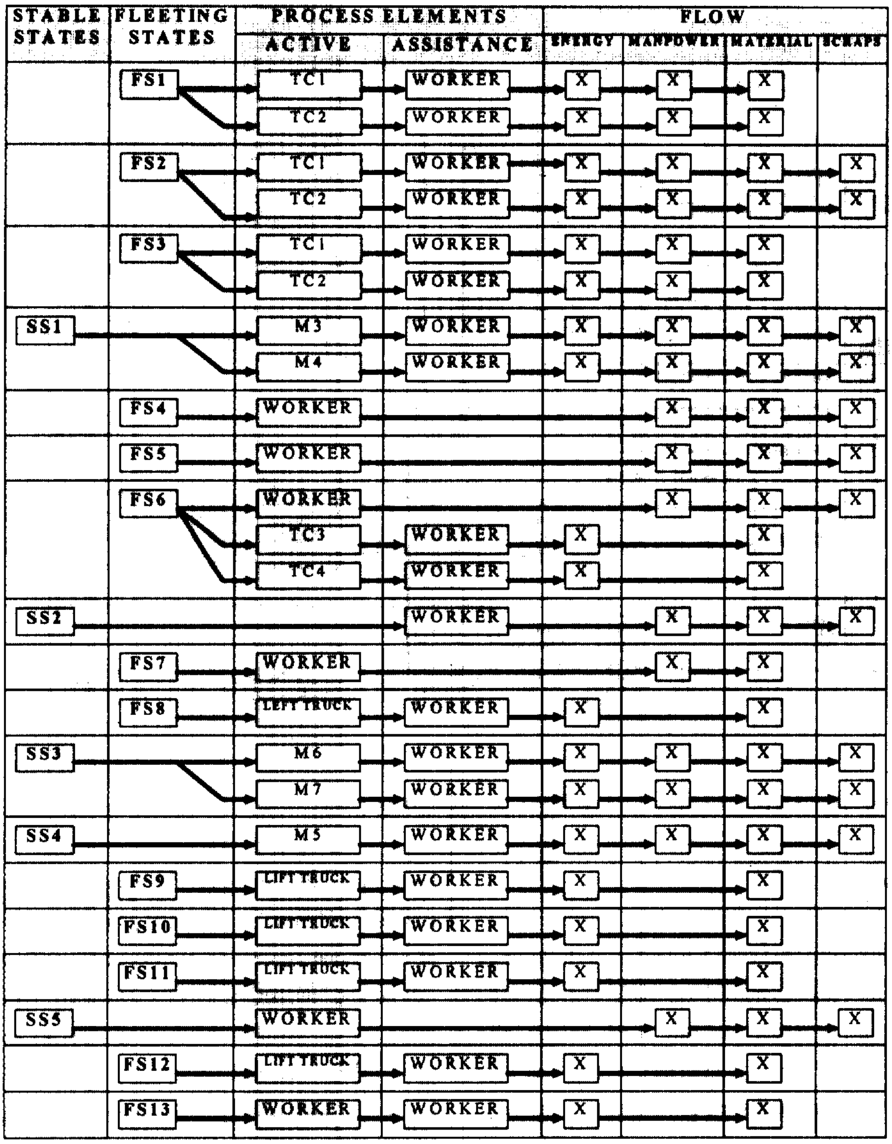
〈Figure 5〉 SADT diagram

4.4 Achronic board

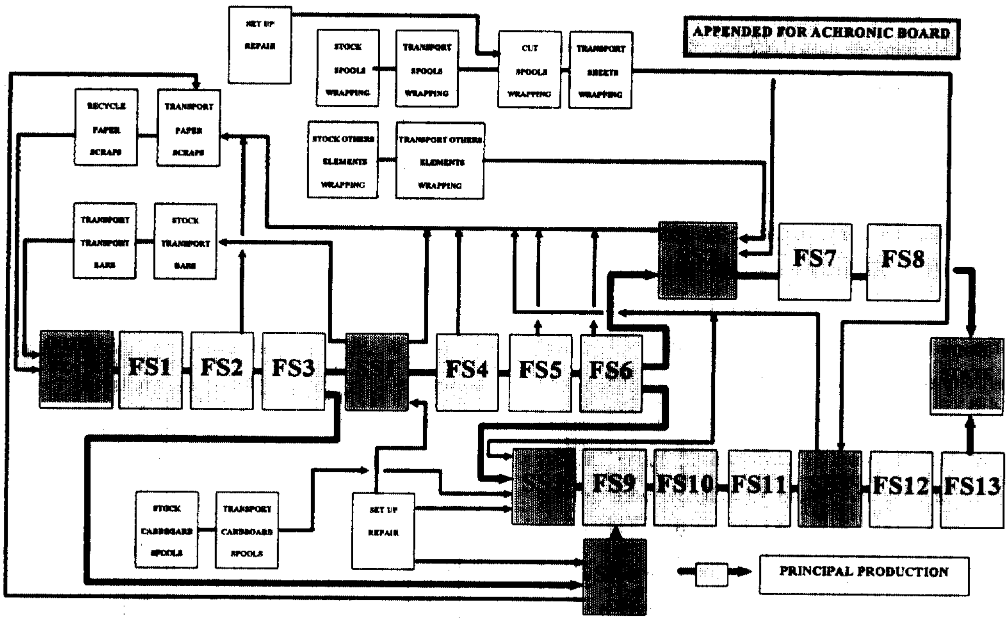
Achronic board is used to decompose a process with fleeting and stable state. They are composed of stable and fleeting states, all active elements which take part in the process, all assistance elements which permit at machines to carry out the operation and finally all flow entity(energy, material, manpower, ...). In this kind of board we see again flow which participate at the realization of stable states and which participate at the obtaining of fleeting states. Achronic board permits a good visualization of costs which are the result of fleeting states and which will have to be eliminated in the future process. Achronic board is constructed from principal production line of FAST diagram because it is only in this line that the product is modified. The principal production line is in fact the representation of product flow. FAST diagram and achronic board show the importance of workers in the process (all assistance organism is a worker). The reason is the poor level of automation concerning transport and stock stages.

With the number of crosses presented with the achronic board ,we can calculate that fleeting states are more than stable states (62.7 % against 37.3 %). The problem is that these steps are not a value added for the product and are characterized by important production costs. In the following board, we represent the percentage of crosses according to fleeting or stable state and according to each flow.

It will be absolutely necessary for the future process organization to reduce the fleeting states in order to eliminate or reduce unnecessary costs. Minimization of transport distances, improvement of material handling, improvement of facilities layout are the ways of cost reduction.



〈Figure 6〉 Achronic board



〈Figure 7〉 FAST diagram

FLOW	ENERGY	MANPOWER	MATERIAL	SCRAPS	TOTAL
FLEETING STATE	19 %	12.3 %	24.6 %	6.8 %	62.7 %
STABLE STATE	6.8 %	10.9 %	10.0 %	9.6 %	37.3 %

5. DESIGN OF ALTERNATIVE LAYOUT SOLUTION

The objective of this part is to solve layout problems presented in the previous sections. Alternative solutions are generated by considering working environment, workers safety, facilities layout, appropriate location and size of storage area, reduction of transportation and setup time. In order to redesign facilities layout for an industrial process, the value analysis method suggests to decompose solutions research in two parts : the first studies the solution for an ideal solution and the second gives realistic choice according to possible investments of the firm. Each choice in this part is justified by specifications presented in the section 3 and by the results of the section 4.

We can make an ideal solution without considering investment cost or realistic possibility of modifications inside the plant. It is very difficult to modify or reorganize the existing plant layout in operation. Indeed the production line can't be stopped for a long time and moreover it is obvious that the factory can't be changed completely. However, the ideal solution of the plant layout will give a reference for a realistic layout solution. The realistic solution can be obtained by slight modification of the ideal solution in order to reflect some realistic constraints based on the current layout. To reveal the realistic constraints in relation with the current layout and necessary investments, it is firstly necessary to consider what are the limitations in the modification of the current layout.

Three types of facilities can be thought to have limitations in movement bacause of their wheight or cost of movement. Machines M0, M1 and M2 to produce paper and to wind the paper around a spool can't be separated and moved bacause of their wheight and size(750 m^2). The recycling trash M8 is connected with the machine block(M0-M1-M2) under ground to recycle the paper scraps. Main traveling crane is located in the center of which we call critical place in the previous part. Movement of the crane is also very difficult because it would be necessary to redesign the crane system itself. Thus, we have decided to abandon movement of these facilities.

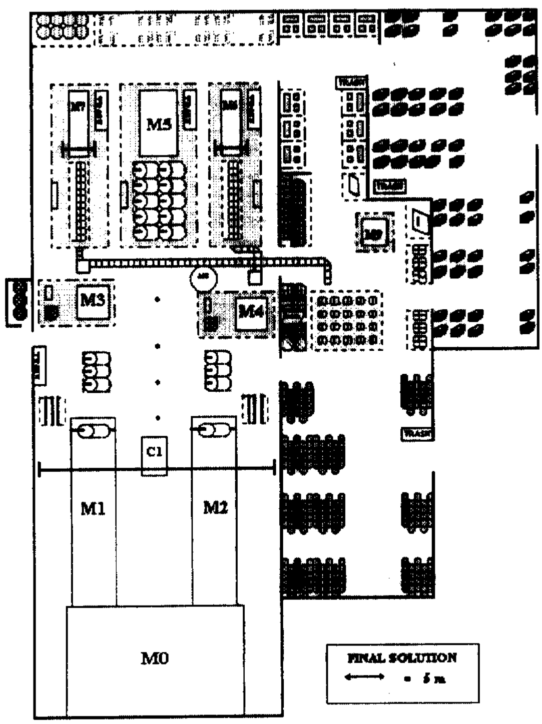
According to above limitations and the ideal solution, we can generate a final plant layout solution specifying what are to be modified in order to improve material flow and general working environment. The two main priorities in relation with overall plant layout are the improvement of materials flow and the improvement of the working environment. Value analysis method suggests a table in ⟨Figure 8⟩ to know what are the priority investments which must be made. We evaluate all possible changes in the layout in view of improvement of material flow and working environment in 100 point scale. It is very difficult to quantify exactly this kind of data. Thus, we can use these data evaluated qualitatively as a guideline for the importance of each modification. The invest requirements are also considered in similar manner. Considering all the present limitations and all possible locations for the final layout solution, we can decide the real location of each machine and the modification of outside walls and inside

Solutions	Improvement material flow	Improvement Working environment	Total	Priority	Investment	Ratio
Roller conveyor	15	15	30	3	8	3.75
Line on the ground	1	2	3	11	1	3
Ground repair	3	5	8	7	8	1
Move M3	2	2	4	10	8	0.5
Move M4	25	10	35	2	10	3.5
Move M5	5	2	7	8	8	0.875
Move M6	5	5	10	6	5	2
Move M7	2	2	4	10	5	0.8
Move M9	10	10	20	5.	1	20
Move outside walls	12	15	27	4	20	1.35
Move inside walls	18	20	38	1	15	2.53
Ergonomica (light, temperature, etc.)	1	7	8	7	8	1
Tools shop	1	5	6	9	3	2
Total	100	100	200		100	

⟨Figure 8⟩ Comparison of alternatives for the plant

separations based on the priority of each modification.

⟨Figure 9⟩ shows a reasonable solution for the layout of the firm. Main changes are location of M4, M5, M6, and M7. In special, modification of location and direction of rewinder machine M4 is very important. The reason is that its location and direction brings about complex loading action and bottleneck of material flow. A type of roller conveyor system is suggested between rewinder(M3, M4) and each cutter(M5, M6, M7) to transport paper rolls easily. However, the location of M4 is slightly constrained by the limitation of M8 movement. This final solution is similar to the ideal plant considered in prevoius stage. Thus, consideration of the ideal plan is useful to give the resonable final solution.



⟨Figure 9⟩ Final solution

6. CONCLUSION

We have suggested a layout design for a paper firm. The present layout of the company has many problems. The materials such as spools and rolls can't flow smoothly because of ill designed layout. Thus, the floor of the plant is very complex and has many in-process inventory. Thus, this paper has suggested a resonable layout design of facilities using value analysis method. It is important to clarify that all choices (facility layout, location of stocks and stores, safety policy) are the direct consequences of the specifications specified in the functional intern analysis. Main purpose of this paper is to describe that value analysis method can be applied to generate a layout design of the plant. It is, however, necessary to verify the given layout solution. The evaluation of the given layout solution is left in later work.

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Eyheraguibel Laurent

He received Associate's degree of thermical and energetical from Institut Universitaire de Technology(1993) and Master' degree in mechanical engineering of Institut Polytechnique de Sevenans(1997). He is interested in System Design, Argonomics, and Value Analysis.

정병호

현재 전북대학교 산업공학과에 부교수로 재직중이며, 한양대학교 산업공학과에서 공학사(1983), 한국과학기술원 산업공학과에서 석사(1985), 박사(1989) 학위를 취득하였다. 주요 관심분야로는 Multi-attribute Decision Making, Simulation Modeling, FMS 등이다.

이찬기

1993년 전북대학교 산업공학 학사
1993~96년 해군 중위 복무
현 재 전북대학교 산업공학 석사 과정
관심분야 FMS, 물류 자동화, 생산 시스템 시뮬레이션

이상영

1994년 숭실대학교 산업공학 학사
1994~95년 대한전선(주)
현 재 전북대학교 산업공학 석사 과정
관심분야 안전관리, 품질 공학, 신뢰성 공학

97년 3월 최초 접수, 97년 8월 최종 수정