International Invention of Scientific Journal
Available Online at http://www.iisj.in
eISSN: 2457-0958
Volume 03 | Issue 03 | March, 2019 |

Original Article

OPEN ACCESS

Improvement of the Task Execution Deadlines on the Plant Construction Project

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Received: February 25, 2019
Accepted: March 03, 2019
Published: March 04, 2019

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Abstract

This paper presents a work on "improvement of the task execution deadlines on the plant construction project". It was written in a context where the mismatching for structural steel in developing countries is growing. The overall objective of this work is to see how to plan a construction project that has lagged in the execution of tasks, and then reduce this accused delay. To achieve this goal, the adopted methodology begins with an analysis of the study site construction methods, after that the data collection comes, including tasks still to be carried out, followed by a choice of methods to be used and, finally, project planning. The planning methods used are work breakdown structure and the Gantt chart, to which time deadline reduction methods such as overtime planning, night work and resource addition were applied. The completion deadlines of this project were reduced by two months. By comparing the investment cost to achieve this reduction and the financial losses caused by the delay, it is easy to see the importance of the proposed solution. This work will allow companies to avoid losing the profit they would have made if they were producing and this profit often turns out to be enormous.

Key Words: Deadline reduction, Gantt chart, Project planning, Scheduling, Steel factories

Introduction

Developing countries have a great need for construction material companies that will help them build the structures they need for their development. Steel factories are particularly necessary because steel has become one of the most widely used building materials. However, the delivery of steel plant construction projects within the contractual deadlines is a perpetual challenge for contractors because they are not immune to unforeseen construction circumstances and the difficulty of managing the projects. In addition, the delay induces financial penalties which can be enormous for the customer and other stakeholders. To achieve the desired objective the structuring of this work first includes the generalities on the constituent elements of a steel factory construction project and project management software. Then comes the study of project planning methods. Among the range of project planning methods that exist, four planning methods have been presented in this work. They are: The Program Evaluation Review Technique, the Gantt chart, Work Breakdown Structure, and the

Critical Chain Method. Execution deadline time reduction methods were also presented, including resource addition, outsourcing, overtime planning, accelerated construction, and critical chain. Then comes the planning methods, reduction of the deadlines and the methodology to follow to implement the chosen solutions. The presentation of the results obtained by applying these methods to a given project and a study of the impact of the planning on the project are presented at the end.

Material

Constituent Elements of the Construction Project:

The construction project shown in Fig.1 consists of the units of the steel plant, the first of which is a scrap unit that collects, and stores purchased scrap. This unit is made up of a weighbridge that permits weighing of the purchased scrap, a rolling bridge that carries the sorted scrap into the furnace and a scrap compactor that will compact the scrap to maximize the quantity entering the furnace. The second material is the electric arc furnace that melts scrap metal with electrical energy at very high temperatures. According to (Jean-François BOURGEOIS and *al.*, 2008) the furnace can function by electrical induction or by an electric arc, by electric bombardment, or laser. In this work, the electric arc furnace is considered. The third material is the ladle furnace, which is used for secondary metallurgy. Adjustments to the desired mechanical properties of the steel are made in this furnace by altering the chemical properties such as: carbon concentration, phosphorus concentration, sulphur content and the oxygen content. The fourth material is the continuous casting machine which serves to mould the molten metal with square-profile moulds while cooling. This machine comprises a conveyor which conveys the slab to the station where it is cut to the desired size, either automatically with an automatic torch or manually with an oxygen torch. The steel billets are then transported to the storage site. The fifth equipment is a compression unit that allows pneumatic equipment to be supplied with compressed air. It is made up of air compressors that increase the air pressure. According to (Ludovic CUVELIER, 2016), there are several types of volumetric air compressors, namely: piston compressors, vane rotary compressors, and screw compressors. The volumetric piston compressor is the most widely used in the industrial environment. The sixth equipment is a fume treatment plant that removes waste from smoke from the two furnaces. The seventh equipment is the water treatment plant that treats the water that will be used for the cooling of machines, by chemical softening and reverse osmosis processes, as well as the cooling of this water. It consists of centrifugal pumps for pressurizing water, cooling towers for lowering the temperature of water, reservoirs for collecting waste water or storing treated water, and heat exchangers for water cooling. The eighth material is the oxygen plant which is present only in factories that use an oxygen torch. It makes it possible to produce oxygen from natural air. It also makes it possible to produce nitrogen which is used to clean the gas pipes. The ninth material is the static var compensator that compensates for the reactive power circulation on the power grid and reduces the effect of load fluctuations. It consists of large reactors and small reactors.

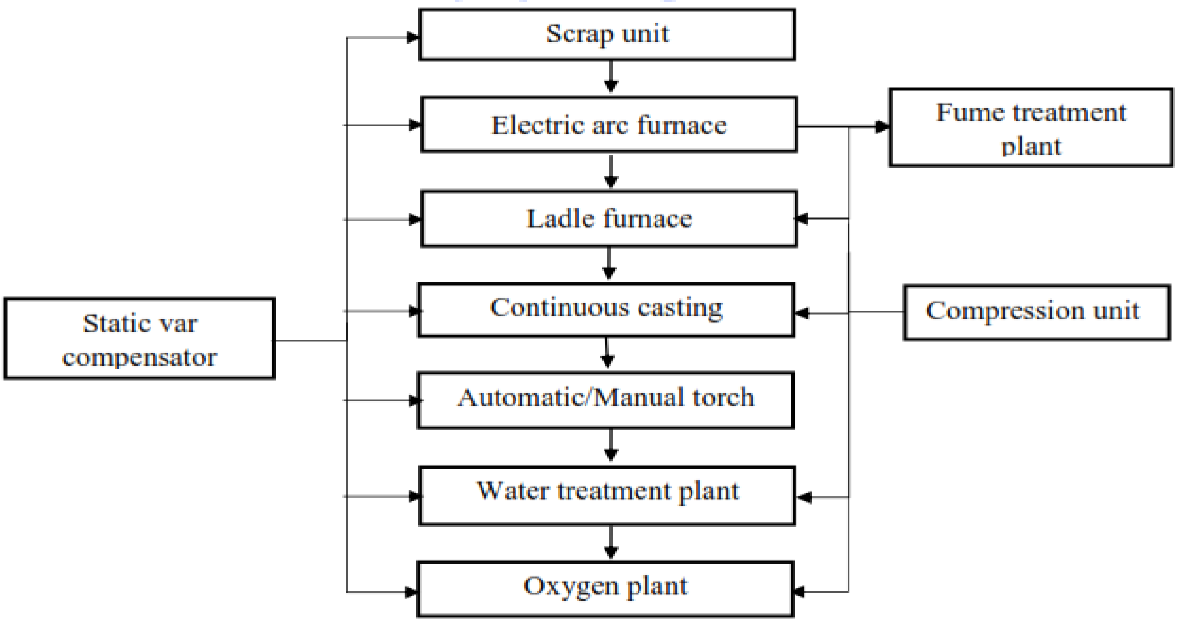

Figure 1: Constituent elements of a steel factory

Project Management Software:

There are different types of project management software which aim at facilitating work. They generally automate tasks and time management, and project planning. There is many project management software, but this work is based on the research conducted by (TSE Ernest, 2017), which presents six project management software: Fitnet Manager, Genius Project, Microsoft Project Professional, Planzone, Sciforma, and Smartsheet. The choice of which project management software to use depends on the type of project carried out and the constraints on the field for a case. The criteria used to compare the six-project management software's are: the ability to use the software collaboratively across multiple machines, the software's planning capability, offline software availability, resource management capability, and the cost of purchasing the software licenses. The result of the research is presented in Table 1 below. It made it possible to choose the project planning software to be used. By comparing the characteristics of the software with the constraints, it emerges that Microsoft Project Professional software is best suited for planning in this case.

Table 1: Comparative study of project management software

Criteria / Software	Collaborative software	Planning	Available offline	Resource management	Cost (CFAF)
Fitnet Manager	Yes	Yes	No	Yes	1.574.300
Genius Project	Yes	Yes	Yes	Yes	1.761.850
Microsoft Project Professional	Yes	Yes	Yes	Yes	682.650
Planzone	Yes	Yes	No	Yes	983.950
Sciforma	Yes	Yes	Yes	Yes	470.000
Smartsheet	Yes	No	No	Yes	520.000

Method

Project Planning:

According to (Alain COURTOIS, 2003) research, the procedure to follow for the planning of the projects by the Gantt diagram consists of five stages. It begins with the fixing of the project to be carried out: it consists of defining the project (specifications) that one wants to achieve and its scope. After defining the project to be carried out, we define the different operations to be carried out: It consists of listing and prioritizing all the operations that will be carried out because the diagram will not be useful if it does not include all the activities necessary to the project or for a project phase. The hierarchy is done with a work breakdown structure. Then comes the definition of the duration of each operation: It consists of the supervisor and his team estimating the duration of each task and the earliest start date. Then you have to define the links between these operations: Some tasks must be completed before others start and others cannot finish until their precedents are finished. Finally, you have to enter all these activities in a software or template: This can be done by hand or using a planning software such as Microsoft Project Professional that was chosen earlier.

Reduction Deadlines:

After planning the project with the software, you have to apply the deadline reduction methods that have been chosen. This can be done by modifying the data that has changed, such as work schedules, the number of workers on a task, and the number of machines to be used to perform a given task. After having entered all this data and recalculating the project in the software. The latter recalculates the project to reduce the deadlines of a task according to the algorithm illustrated in Fig. 2 below. The software first checks if the capacity allocated to the task has changed. If this is the case, it converts the duration of the task to days/man and divides this duration by the new capacity and moves to the next line. If the allocated capacity has not changed, it does nothing and moves to the next line.

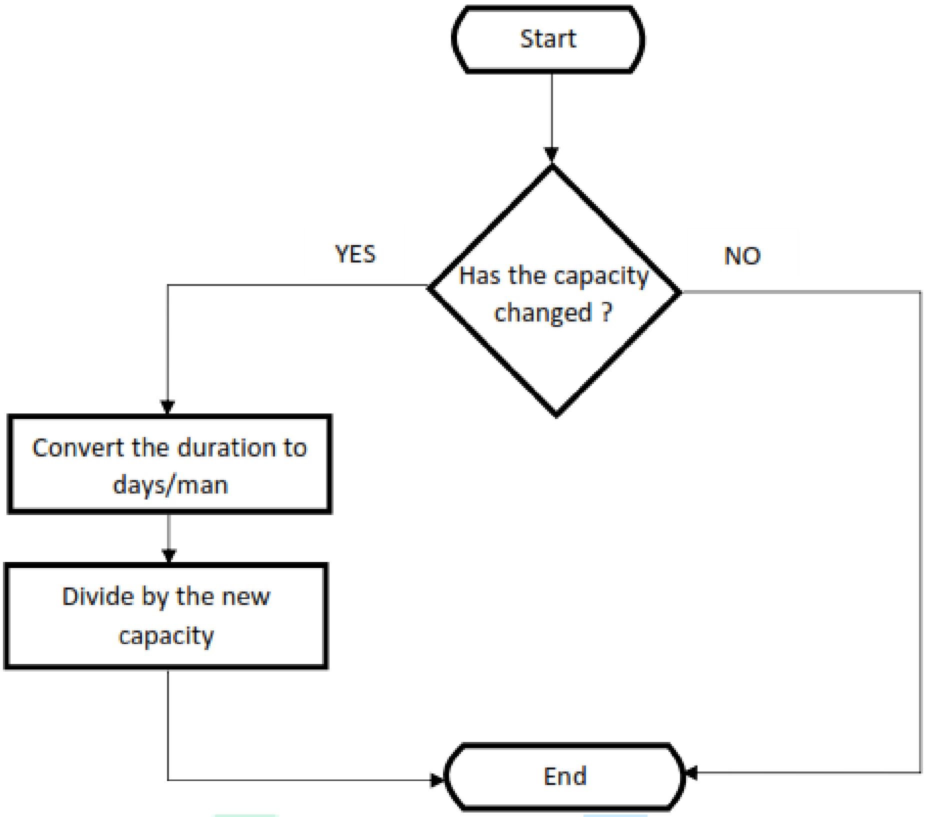

Figure 2: Task deadline reduction algorithm used by software

Having night work as a solution, it will be necessary to think of appropriate lighting of the construction site to allow workers to do their job well. According to (R. CHUDLEY and *al.*, 2008), the number of lighting poles to be installed is given by eq. (1) below:

$$N = \frac{Required\ luminous\ flux\ (lm)}{Luminous\ flux\ of\ one\ lighting\ pole\ (lm)} \quad (1)$$

Whereas lm is lumen and N is number of lighting poles.
1 lm = 1 $cd\ sr$, and cd is candela, sr is steradian.
The luminous flux of an illuminating mast is obtained from the power of the lighting mast and the type of lamp. This value is often written on the carton of the lamp.

The required luminous flux is obtained from the eq. (2) below:

$$Required\ luminous\ flux = Surf.area\ to\ light \times Luminance\ (lx) \quad (2)$$

Whereas lx is lux and 1 lux = 1 $cd\ sr$ (m^{-2}).

The luminance is obtained from the chart shown in Table 2, which was taken from the book by the (Health and Safety Executive, 1997). It depends on the location or type of work. In our case, the luminance chosen is 200 lux because the construction works require the perception of details.

Impact of the Planning:

To measure the impact of the planning that has been established, a financial analysis of the proposed solution was carried out by calculating the expenses generated by the application of the solution as well as the losses incurred per day of non-production at the factory. First, the cost of recruiting new staff, the cost of overtime work, and the cost of software and new material were calculated.

Then, a calculation on the losses realized by the company per day of the delay of the project was done. To do this, the gain that the company would have made if it produced was calculated. This calculation was carried out with the eqs. (3) to (8) as follows:

$$f = \frac{Q_{ac}}{Q_f} \times 100\% \quad (3)$$

Whereas Q_{ac} is quantity of steel produced per casting in tons, Q_f is quantity of scrap used per casting in tons, f is percentage of scrap converted to steel.

The cost of scrap used per day is given by eq. (4) below:

$$C_f = Q_f \times \frac{p_f}{1000} \times \frac{24}{t_c} \qquad (4)$$

Whereas C_f is cost of scrap per day, p_f is purchase price per ton of scrap in CFAF, t_c is time between 2 castings in hours.

Table 2: Minimum recommendations for night lighting

Activity	Typical location/ type of work	Average luminance (*lux*)	Minimum measured luminance (*lux*)
Movement of persons, machines and vehicles	Lorry parking, corridors, circulation way	20	5
Movement of persons, machines and vehicles in hazardous zones; roughing work which does not require perception of details	Cleaning of a construction site, ground works, loading areas, bottling factories and conservatries	50	20
Work that require a limited perception of details	Kitchens, factories, assembly of large parts, pottery	100	50
Work that require perception of details	Offices, sheet metalworks, binding	200	100
Work that require a fine perception of details	Drawing offices, electrical components assembly factories, textile production	500	200

To obtain the amount of steel produced per day, the following eq. (5) is applied:

$$Q_{ap} = Q_{ac} \times \frac{24}{t_c} \qquad (5)$$

Whereas Q_{ap} is amount of steel produced per day in tons.

And the total price of steel produced per day is given by eq. (6):

$$C_{ap} = Q_{ap} \times p_a \qquad (6)$$

Whereas C_{ap} is cost of stel produced in CFAF, p_a is price of one ton of steel in CFAF.

The consumption of electrical energy per day throughout the plant is given by the eq. (7) below:

$$C_E = (c_{ept} \times Q_{ap} \times 85) + (3700 \times P_s) \qquad (7)$$

Whereas C_E is electricity cost per day in CFAF, c_{ept} is electrical consumption per ton in kWh, P_s is subscribed power in kW.

From the above-calculated costs, the daily production gain obtained is presented on the eq. (8) below:

$$Daily\ production\ gain = C_{ap} - C_f - C_E \qquad (8)$$

Results and Discussion

Work Breakdown Structure:

Fig. 3 below shows the hierarchy of deliverables and main tasks of the construction project. It consists of three levels so as not to over-detail and make the chart difficult to use.

Task List and Precedence:

The tasks list and precedence (Table 3) lists the tasks to be carried out as well as their durations and constraints precedence. It is obtained from the task flow chart by detailing the deliverables in elementary tasks.

Planning for Task Deadline reduction:

By applying the aforementioned planning steps, the basic Gantt chart shown in Fig. 4 below was obtained.

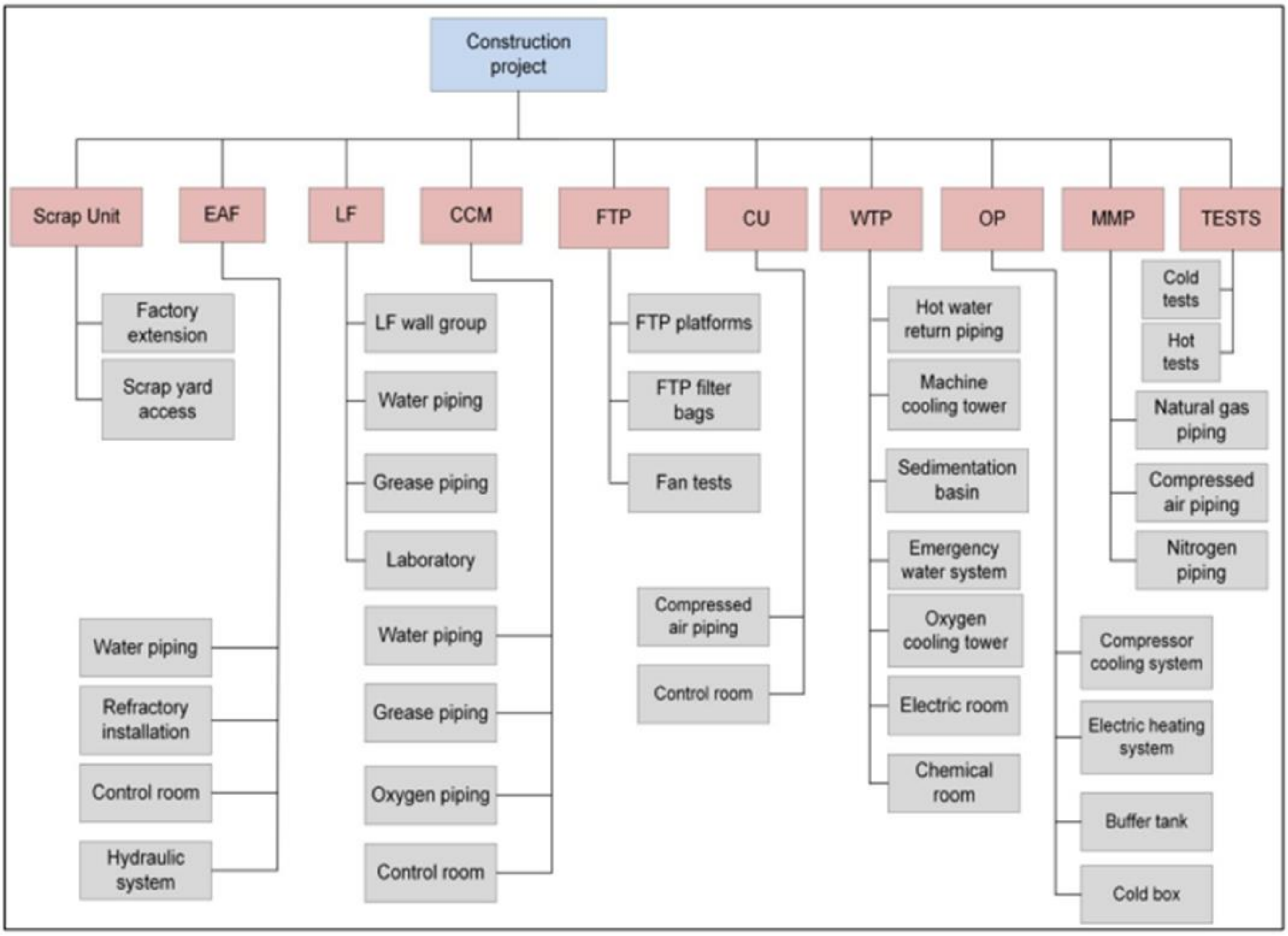

Figure 3: Work breakdown structure

Table 3: Summary of the sizing result

No.	Task	Duration	Predecessor
1	SCRAP YARD	171.5 days	
2	Factory extension	124.5 days	
3	Foundation works	62.5 days	
4	Pillar erection	30 days	3
5	Floor cementing	12 days	4
6	Construction of metallic framework	20 days	5
7	Civil works on the scrap shredding machine	10 days	5
8	Scrap yard access	67 days	
9	Foundation works	20 days	5
10	Parking	14 days	9
11	Security agents building	3 days	10
12	Construction of the access highway	30 days	11
13	EAF	91 days	
14	EAF water inlet around EBT piping completion	5 days	
15	Finishing of EAF wall group	5 days	14
16	EAF electrode arms positioning	4.5 days	15
17	Refractory installation	50 days	
18	Refractory special cement block production	30 days	57

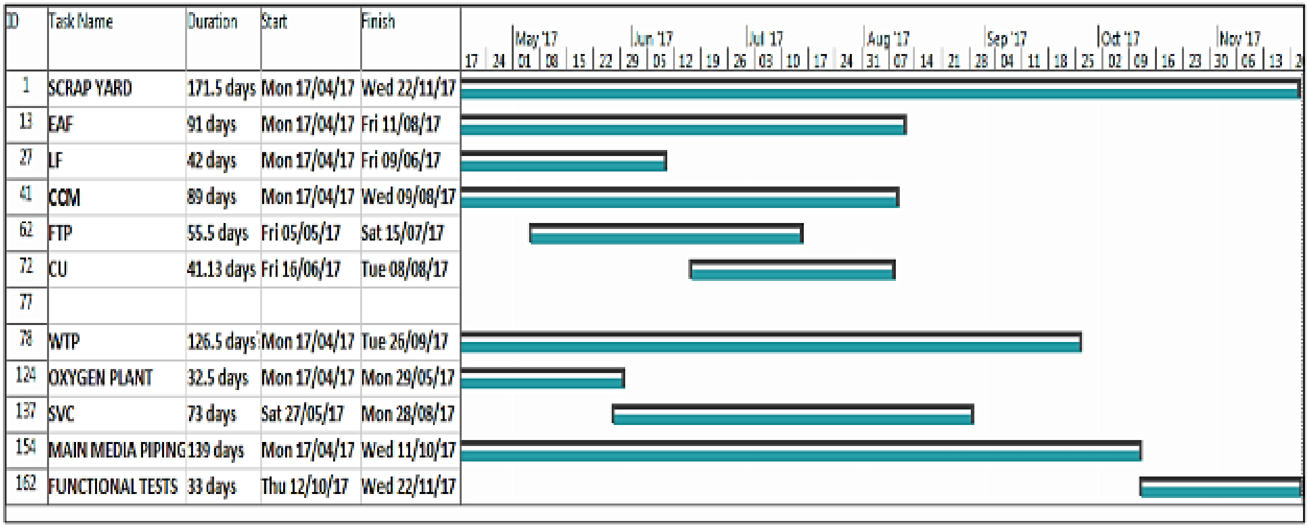

Figure 4: Basic summary of Gantt diagram

To reduce turnaround times, the use of overtime hours of two hours per working day and four hours on Saturdays was applied. Sunday is chosen as the day of the week for obligatory rest of twenty-four hours per week according to the laws in force. Night work was applied with schedules that range from 10 pm to 5 am with a one-hour long break. For night work, the number of lighting poles was obtained from the eqs. (1) and (2). Table 4 below gives the results of the calculation of the number of lighting poles.

Table 4: Calculation of the number of lighting poles

Type of lamp	Luminance	Surface area to light (m^2)	Luminous flux per lamp (lm)	Number of lighting poles (N)
Low pressure sodium discharge lamp	200 lux	3540	60.000 lm	12

Based on all of the above, the Gantt diagram with the summary tasks is shown in Fig. 5 below. It brings the end of works to ending October 2017 as illustrated on the diagram, which is a gain of one month with respect to the basic Gantt diagram (November 2017) and two months on the initial project delivery date (December 2017).

Impact of the Planning:

Applying the eqs. (3) to (8) to the data of the problem, the values presented in Table 5 below are obtained:

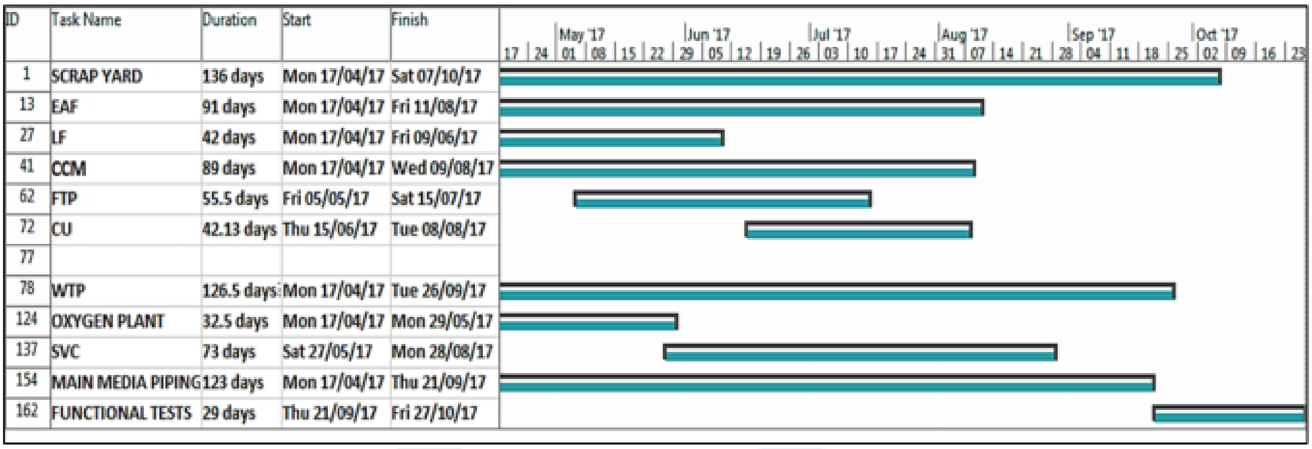

Figure 5: Optimised summary Gantt diagram

Table 5: Impact of planning

C_{ap} (CFAF)	C_E (CFAF)	Cost of scrap (CFAF)	Daily production gain (CFAF)	Cost of the solution (CFAF)
99.370.425	16.571.805	43.129.600	**39.669.020**	**71.764.685**

The cost of the solution, which amounts to CFAF 71,764,685, is very small compared to the value of the daily production of the plant which amounts to CFAF 39,669,020. It is better to invest on the solution that saves two months on the execution of tasks and quickly recover this money as soon as production is launched.

Conclusion

This work was focused on «improvement of the task execution deadlines on the plant construction project ". The objective of this work was to plan a construction project that got delayed reducing the time required to complete the tasks. To accomplish this work, several steps were necessary: knowing the different planning methods, reducing deadlines and various project management software; analyse the construction methods used on site and identify defects and also collect data; process using the Microsoft Project Professional software and apply the deadline reduction methods. The schedule set up allows to reduce the execution time by 2 months. This improvement is reflected in the gain that the company will make by applying the solution. Indeed, the company loses a production value of about 40 million per day of non-production.

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