Assembly project management of a suspended conveyor

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Abstract. Modern manufacturing systems are characterized by the fact that they integrate various machines and work equipment, industrial handling robots, industrial robots performing technological operations (welding, riveting, painting, etc.), transfer systems (conveyors, conveyor belts, automated guided vehicle -AGV), storage systems and inspection stations. The paper presents the way in which the assembly project management of a suspended conveyor system was carried out. Critical path method was used. It has identified the assembly operations, the way they succeed in the technological process of assembly, the duration of the operations and the resources (labor force) necessary for their realization. This information has been processed through Microsoft Project resulting in critical activities (critical path), project duration, the ratio between the available and necessary resources (in the analyzed case a significant deficit of the machinist resource) and the corresponding costs. In order to solve the problem of resource requirements, two solutions were used: leveling resources and supplementing them in order to reduce the duration of critical activities. Finally, a version of the conveyor assembly project management resulted in a balance between costs and duration.

1. Introduction

The project management of the conveyor assembly will be done by applying the critical path analysis methods. Critical path analysis defines a scientific discipline for the implementation of projects using graphs theory. In the theory of the Critical Path Analysis Method, the project means a high intensity action or a complex process that has the objective a well known and defined result [1].

Critical path method is commonly used in the production management of unit type and not only Assembly processes can be managed through these methods. Thus, the paper [2] delves into the scheduling of complex assembly lines with workforce constraints. This paper presents an extended Critical Path Method (CPM) using a simulation approach to calculate probable Critical Paths of the projects. A new algorithm that obtains an approximation of the Critical Path in schedules generated using the disjunctive graph model that represents the Job Shop Scheduling Problem (JSSP) is presented in [3]. The study [4] aims to perform the best scheduling project of the empennage structure design of Indonesia's aircraft with limited resources. Critical Path Method is used to schedule the project based on activity and resource.

The paper [5] shows how the critical path method was used in the project management and execution of automatic detergent packaging equipment. The paper [6] proposes using the Critical Path Method for Making Process Layout of a T-Shirt within Earliest Finish Time.

This paper presents the way in which, using the critical path method, the assembly activity for a conveyor transfer system was managed.

2. Defining the activities of the conveyor assembly project

The conveyor is designed for the transfer of components on assembly lines in the automotive industry but can be adapted to carry tasks specific to other areas of activity. The designed and constructed conveyor is a suspended type and carries individual loads between the loading and unloading stations on the technological route. The track on which the conveyor works is a complex one, consisting of linear and curved segments, arranged horizontally or inclined at an angle of 30 ° and is a maximum length of 15m. In figure 1 is presented the 3D model of the conveyor that is the object of the work, and in figure 2 the conveyor made practically.

The main components of the conveyor are (figure 1 and figure 2): 1- metal frame; 2- drive subassembly; 3- drive gear; 4- trolleys rollaway, 5-transport trolleys rollaway; 6- transport trolleys 7- drive cable; 8- strut; 9- driven gear; 10- electric and command subassembly.

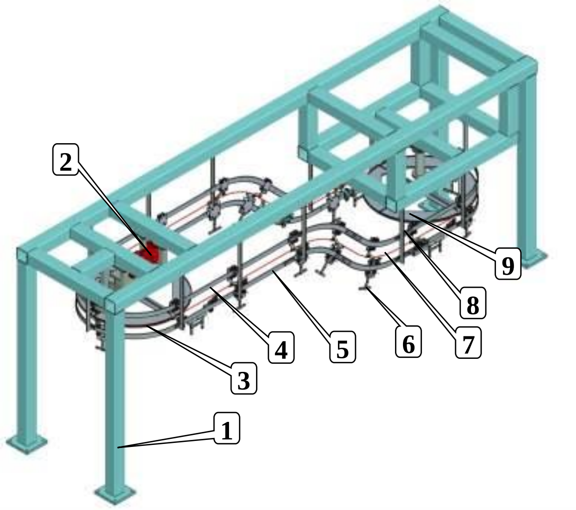

Figure 1. Conveyor - 3D model.

Figure 2. Conveyor made practically.

In table 1 is presented the activities of the conveyor assembly project.

Table 1. The activities of the conveyor assembly project.

Nr. crt.	Name	Time (h)	Predecessors	Resource	Necessary
1.	Frame (metal frame)	0	-	-	
2.	Support motor mounting	2	1	Machinist	2
3.	Side struts mounting	6	1	Machinist	2
4.	Upper Rollaway mounting	8	3	Machinist	3
5.	Lower Rollaway mounting	8	3	Machinist	3
6.	Gearmotor mounting	2	2	Machinist	2
7.	Vertical axis mounting	1	6	Machinist	2
8.	Support bush mounting bearing_1	2	7	Machinist	1
9.	Driver gear mounting	2	8	Machinist	3
10.	Support bush mounting bearing_2	2	2	Machinist	1
11.	Driven axis mounting	1	10	Machinist	2
12.	Driven gear mounting	2	11	Machinist	3
13.	Trolleys mounting	6	4	Machinist	2
14	Cable mounting	3	13	Machinist	3
15	Trolleys mounting	6	14	Machinist	2
16.	Control cam mounting	2	15	Machinist	2
17.	Mounting sensors	2	16	Electrician	1
18.	Electrical cabinet installation	2	17	Electrician	2
19.	Making electrical connections	4	18	Electrician	2
20.	Making pneumatic connections	2	19	Electrician	2

All activities take into account the following associated information: the duration in hours, the activities to be carried out for the conveyor assembly, technological dependencies between activities (predecessors) and the type of resource needed to carry out the activity, the resource requirements.

Table 2 provides information on the available workforce (resources) and on workforce costs.

Table 2. Workforce (resources) available and costs

Nr. crt.	Resource	Type	Available	Standard rate (lei/h)	Overtime Rate (lei/h)	Accrue
1.	Machinist	Work	3	20	40	Prorated
2.	Electrician	Work	2	20	40	Prorated

3. Project implementation in the *Microsoft Project*® program

The project will be implemented in Microsoft Project®. It allows a complex analysis of all aspects of project management: definition of activities, critical path determination, allocation of resources, cost analysis, etc.

The working hypotheses are: it was considered that the week has five working days: Monday, Tuesday, Wednesday Thursday and Friday; the working day has eight hours of work; the program starts at 8 am; the break is between 12: 00-13: 00; the end of the working day is at 1700.

3.1. First version

In a first version, the activities are transferred to the program according to the information in table 1. The Gantt chart is shown in figure 3. The same figure shows the activities that have a resource deficit - the necessary is greater than the available.

The synthesis information regarding the first version in the Microsoft Project® program: the project runs for 5.13 days; the time worked is 157 hours; the labor costs are 3.140 lei.

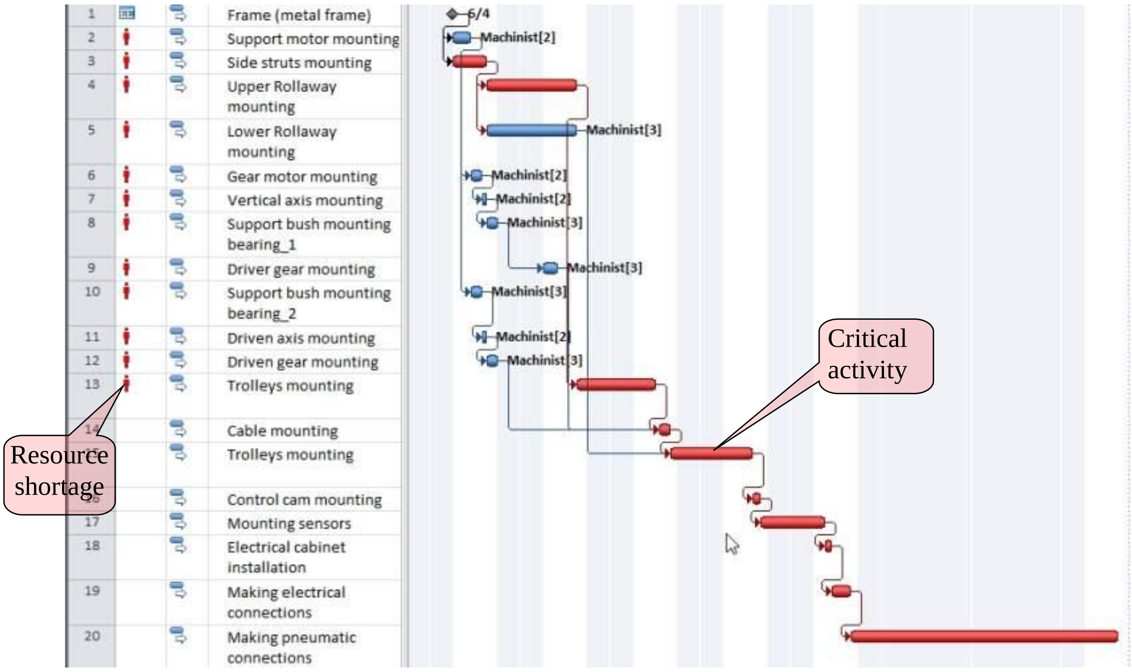

Figure 3. The Gantt chart and the critical path. First version.

The figure 4 shows the *Resource Sheet Tools* window, which makes it clear that the machinist resource is deficient in relation to the requirements.

ID		Resource Name	Type	Material Label	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar
1		Machinist	Work		L		3	20.00 lei/hr	40.00 lei/hr	0.00 lei	Prorated	Standard
2		Electrician	Work		E		2	20.00 lei/hr	40.00 lei/hr	0.00 lei	Prorated	Standard

Figure 4. Description of the ratio between the available resources and the necessary. First version.

In the figure 5, through the Resource Graph Tools option, the ratio between necessary and available resource, for each day of the project is highlighted. Thus, it is found that there is a shortage of 9 machinist resource on Monday 3.06.2018, and 6 machinist resource on 4.06.2018. Figure 6 shows the cost of the machinist resource each day of the project runtime.

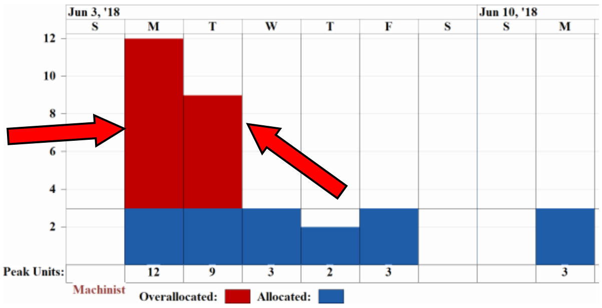

Figure 5. The description of the ratio between the available and the necessary machinist resource - in the Resource Graph Tools window. First version.

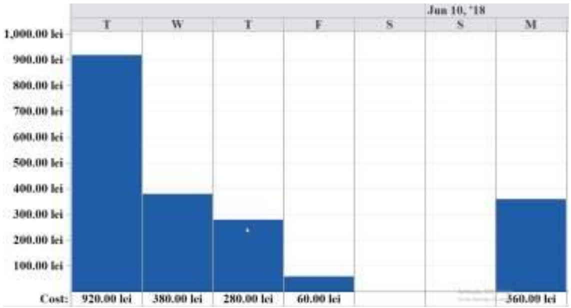

Figure 6. The cost chart with the machinist resource every day of the project runtime. First version.

3.2. Version II

To solve the problem of resource shortage (labor force) in the case of the conveyor assembly project, it can be use a Microsoft Project® feature. This feature is Level Resource. With this option, Microsoft Project® schedules activities so that the necessary resources are not greater than available. The deficit refers to the machinist resource. After applying this feature, it is noted that significant changes occur in the Gantt chart (figure 7). The deficit refers to the machinist resource. After applying this feature, it is noted that significant changes occur in the Gantt chart (figure 7).

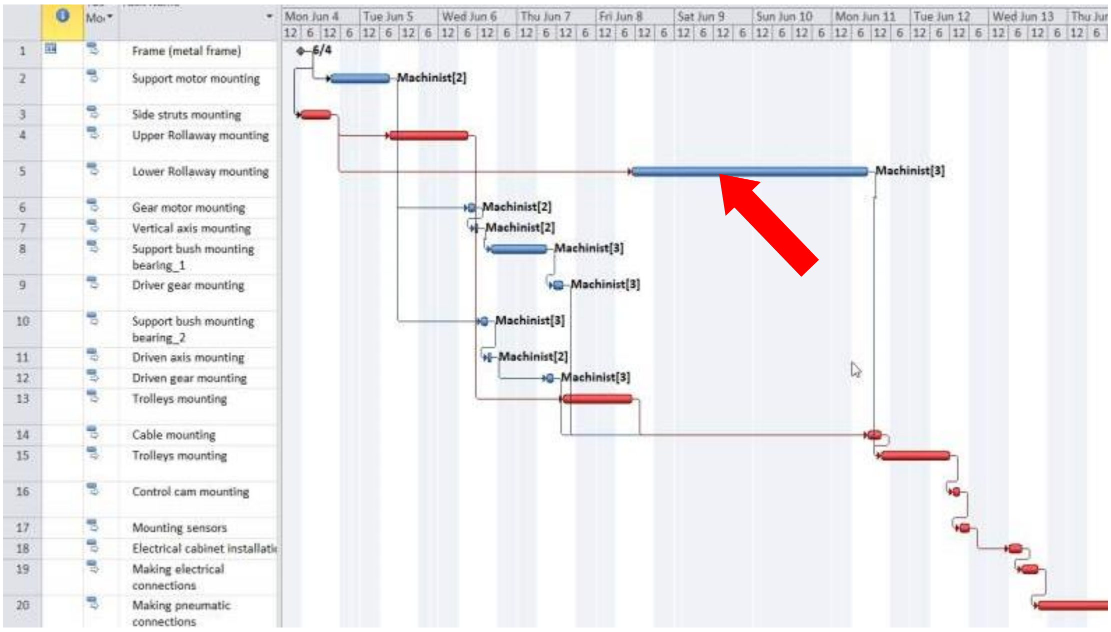

Figure 7. Gantt Chart and Critical Path. Version II.

The beginning of the activity lower rollaway mounting is was offset so that the machinist resource can be used within the limits of availability. It is noticed that there is no shortage of resources. Due to the reprogramming of the activities, the duration of the project changes significantly. Thus, in this version, the project would run for 7,88 days (7 days and 7 hours). The increase in project execution time is 35%, compared to the version I.

3.3. Version III

In order to solve the deficit problem and for a short duration of the project, the following measures are taken: the availability of the machinist resource is increased from 3 to 8; for some of the critical operations, additional resources will be allocated so that their execution time decreases and implicitly the execution time of the project will be shorter.

These operations are: upper rollaway mounting - in the version I 3 machinists are allocated, in version III are allocated 4 machinists; trolleys mounting- in the version I 2 machinists are allocated, in the version III are allocated 4 machinists.

Synthesis information regarding the version III project implementations in Microsoft Project ® are: the project runs for 4.13 days (4 days and 1 hour); the working time is 157 hours; the labor costs are 3.140 lei.

A one-day decrease (meaning 20%) in the duration of the project was found. The cost of the machinist resource is 2780 lei (88.53% of the total), and the costs with the electrician resource is 360 lei. The distribution of the working time on the two resource categories: 139 hours (88.53% of the total) are allocated to the machinist resource and 18 hours to the electrician.

4. Conclusion

Network programming, critical path determination methods, are effective tools for unique production management. These methods make it possible to optimize solutions by taking into account the available resources.

In the analyzed case study - the project management of a suspended conveyor assembly, the critical path method was implemented through *Microsoft Project*®. The first version showed the critical activities and implicitly the critical path that was defined to be the shortest time in which the project can be done. Also in this first variant there was found a significant deficit in terms of the machinist resource. This problem was solved by leveling the resources - programming the activities so that the resources are used within the limit of availability (version II).

However, in order to shorten the duration of the project implementation, the availability of the machinist resources was increased, the duration of the project execution decreased by 20% (version III). The *Microsoft Project*® program provides the decision maker (the project manager) a variety of information that allows him to take the most effective measures to balance the project's duration with costs.

5. References

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