Mixed Model Dynamic Line Balancing and Workforce Planning System

FACULTY OF ENGINEERING AND NATURAL SCIENCES

Student(s)

Furkan Osman Gümüş
Gülriz Güşta Gül
Ertuğrul Taha Atlıhan
Sinem Kurnaz
Mert Katip

Faculty Member(s)

Bülent ÇATAY

Company Advisor(s)

İsmail DÜNDAR

ABSTRACT

TEMSA is an automotive company which produces and distributes buses and minibusses under its own brand in the world market. The problem occurs because of the variety of products that TEMSA manufactures, according to the customer's demand. There are 23 different models and N different variants in TEMSA's product chart however, there is only a one-way assembly line. In order to satisfy the customer's demand in a required time period, there should be a production with several models at the same time. The aim of the project is to develop a line balancing and workforce planning system for the production lines under different scenarios and changing conditions and decreasing the station number so that, the work in process number is going to decrease which causes the company to hold unfinished goods waiting for completion. There are 113 different stations in the line and all of these stations address to a specific implementation with specific expertise. In the current system, daily and weekly plans in the facility are being done by intuitive knowledge.

What we did is to develop a line balancing Linear Programming Model, which's objective function is to minimize the station number with respect to several parameters and constraints. However, we worked on one specific station which is the most complex one because once we create the appropriate model, we can apply the model to all other stations.

OBJECTIVES

- Reduction in the station number
- Reduction in the inventory level of semi-finished products
- Decrease in labor losses
- Reduction in production costs
- Faster response to customer needs
- An effective and user-friendly decision support tool
- Using the resources more efficiently

PROJECT DETAILS

I. Mathematical Programming Model

The project was conducted in three phases. In the first part, the data was analyzed and organized to be used in the CPLEX, which is a software to find the optimal result of the Linear Programming problems. The predecessors' and regions' binary matrix were formed. In the second step, the linear programming model was created and transformed into a CPLEX model. The objective function is minimizing the station number based on the given cycle time. There are fixed tool, maximum and minimum operators, regions and predecessors constraints as it can be seen in the Linear Programming Model. The model was modified several times to make the system better in the change of different parameters. The third step is analyzing the solution's results of the CPLEX model. The current applied system and the CPLEX solution was compared based on the stations and regions. The *Table 1* and *Table 2* are the comparison tables of the result. Also the graphs show the difference of the distributions of the tasks to the stations. It can be observed from the change of the regions in the stations.

Parameters

m Available station number

n Number of tasks

mA_i Minimum number of workers for task i

t_i Total task time of task i

C Cycle time

$$O_{ij} = \begin{cases} 1, & \text{if task } j \text{ is predecessor of task } i \\ 0, & \text{otherwise} \end{cases}$$

Decision Variables

$$X_{ik} = \begin{cases} 1, & \text{if task } i \text{ is assigned to station } k \\ 0, & \text{otherwise} \end{cases}$$

$$Y_k = \begin{cases} 1, & \text{if station } k \text{ is open} \\ 0, & \text{otherwise} \end{cases}$$

Objective Function

$$\text{Minimize } \sum_{k=1}^{m}(Y_k) \quad k \epsilon 1 \ldots m$$

Subject to

$$\sum_{i=1}^{n}(t_i/\text{m}A_i) \times X_{ik}) \leq C \quad \forall_k \quad k\epsilon 1 \ldots m$$

$$\sum_{k=1}^{m}(X_{ik}) = 1 \, \forall_i \quad i\epsilon 1 \ldots n$$

$$\sum_{i=1}^{n}(X_{ik}) \leq Y_k . M \quad \forall_k \quad k\epsilon 1 \ldots m$$

$$O_{ij} . X_{ik} \leq \sum_{s=1}^{k}(X_{js}) \quad \forall_k, \forall_i, \forall_j$$

II. Comparisons

Graph 1

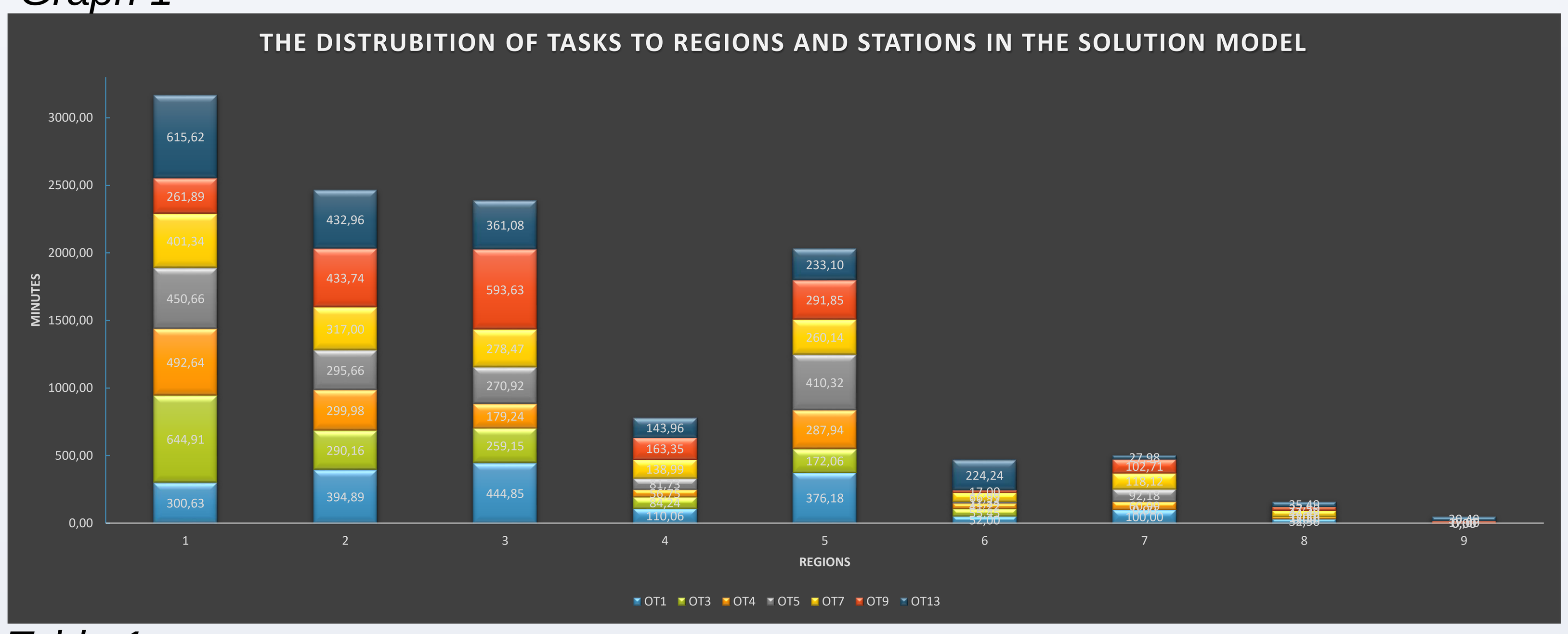

Table 1

THE SOLUTION										
Station Number	Task Done	1	2	3	4	5	6	7	8	9
OT1	81	301	395	445	110	376	52	100	33	0
OT3	74	645	290	259	84	172	55	0	0	0
OT4	61	493	300	179	57	288	41	61	18	0
OT5	75	451	296	271	82	410	11	92	0	0
OT7	61	401	317	278	139	260	67	118	44	0
OT9	54	262	434	594	163	292	17	103	28	17
OT13	79	616	433	361	144	233	224	28	35	30
TOTAL SUM	485	3168	2464	2387	779	2032	468	502	157	47

The Highest Cycle Time	644,91
Bottleneck	Station OT3 Region 1

Graph 2

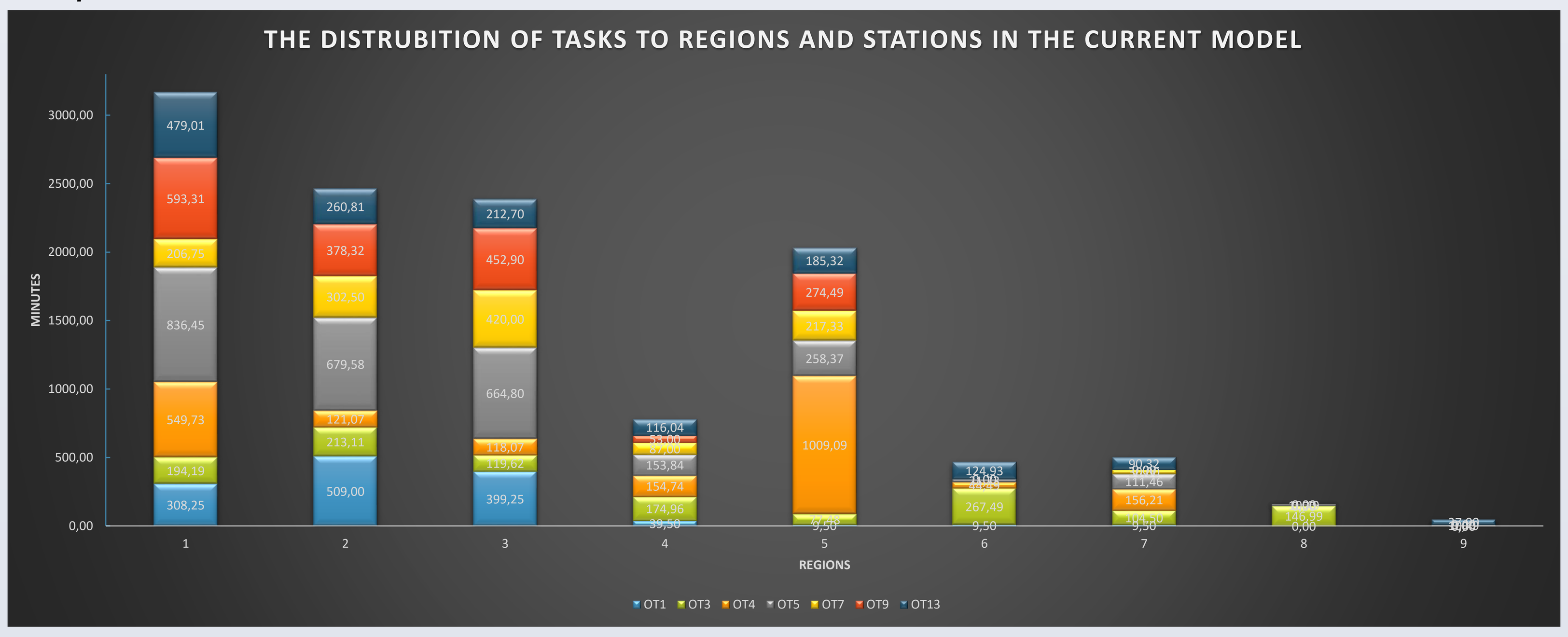

Table 2

CURRENT MODEL										
Station Number	Task Done	1	2	3	4	5	6	7	8	9
OT1	35	308	509	399	40	10	10	10	0	0
OT3	60	194	213	120	175	77	267	105	147	0
OT4	115	550	121	118	155	1009	44	156	0	0
OT5	80	836	680	665	154	258	22	111	10	10
OT7	41	207	303	420	87	217	0	30	0	0
OT9	94	593	378	453	53	274	0	0	0	0
OT13	60	479	261	213	116	185	125	90	0	37
TOTAL SUM	485	3168	2464	2387	779	2032	468	502	157	47

The Highest Cycle Time	1009,09
Bottleneck	Station OT4 Region 5

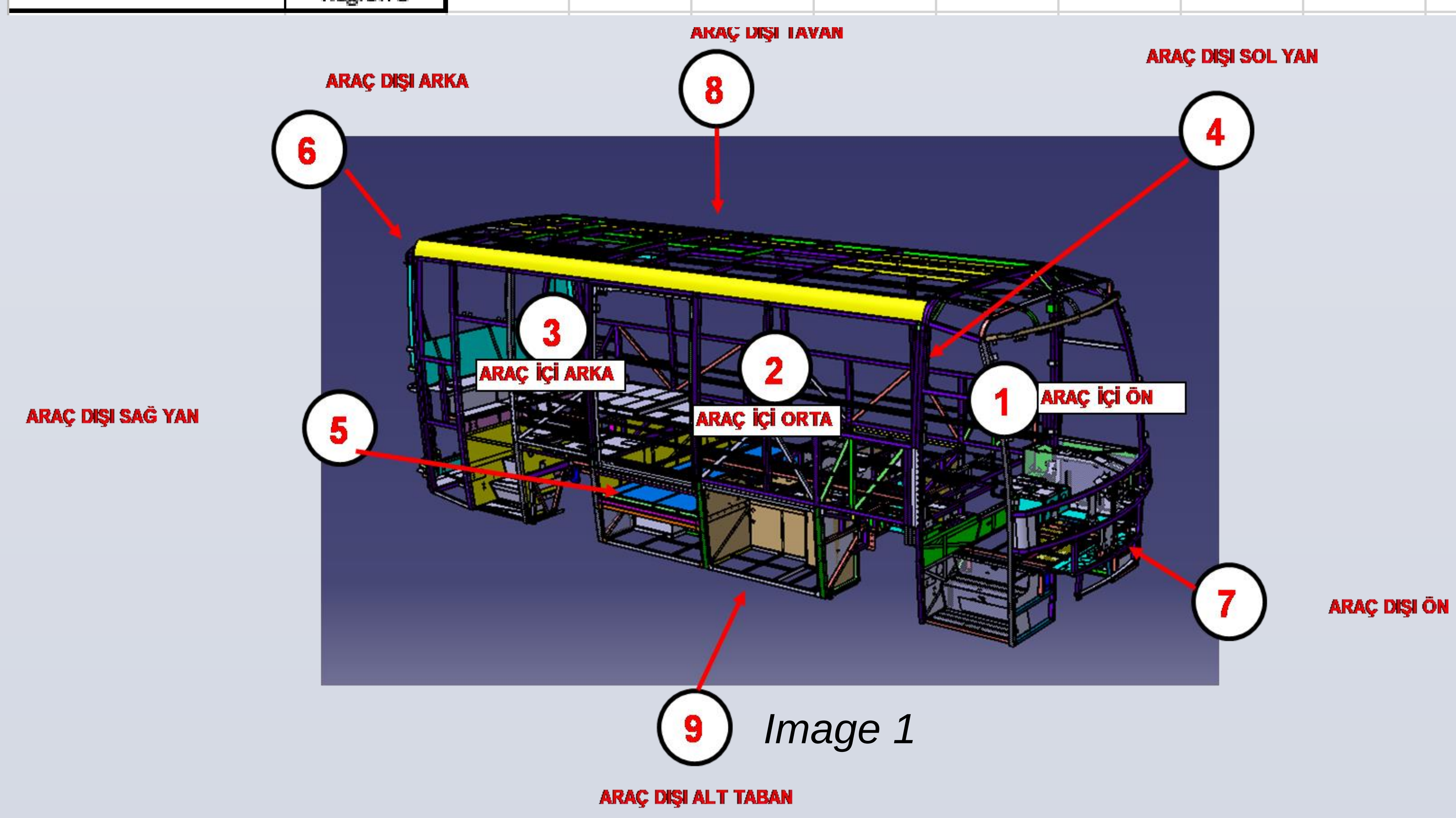

Image 1

CONCLUSIONS

In the last part of the project, the data was collected from CPLEX and made analysis by project group members. We made a table to show the tasks' stations and regions that they were done in the current model and solution model. After that, we compared the results of our system with the current system of TEMSA. As a result of our analysis;

- The tasks and number of tasks done in each stations are different compare to current system of TEMSA.
- The length of the works to be performed in 9 regions (*Image 1*) for each station has been different from the current system.
- We have seen an increase in the number of jobs that can be done at the same time

REFERENCES

Curry, G. L., & Feldman, R. M. (2014). Manufacturing Systems Modeling and Analysis. Berlin: Springer Berlin.

Heragu, S. (1997). *Facilities design*. Boston: PWS Publ.

Sivasankaran, P., & Shahabudeen, P. M. (2016). Heuristics for Mixed Model Assembly Line Balancing Problem with Sequencing. Intelligent Information Management,08(03), 41-65. doi:10.4236/iim.2016.83005