FACULTY OF ECONOMICS AND MANAGEMENT SCIENCE

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

Capacitated Lot Sizing for BMW

Scientific Projects 2020/2021

Motivation

- Lot size analysis can give us insight into the various factors that contribute to the total cost of production. We are always looking at cost effective manufacturing process, in the best interest of the industry
- The close relationship between lot sizing and scheduling makes it imperative that both decisions are made simultaneously in order to efficiently use capacity

Results

Once the heuristic returned a feasible solution using Python, a cost efficient schedule was also devised.

Total inventory cost	Total setup cost	Total cost
€9384.62	€116844	€1,26,228.62

- Week 10 takes a huge dip to €1163.74 in the total cost, when compared to other weeks. This can be attributed to the current pandemic

Outlook

In the future, the results from the heuristic could be further refined by applying the strategies like,

- Intensification: escalates the local search
- Diversification: increases exploration capabilities
- Different neighborhood structures

Research Question

- To develop and implement a heuristic solution approach for the given lot sizing problem
- Generating a cost-efficient schedule
- Minimize the total costs i.e, Setup costs and Inventory Costs for all eleven weeks.

Methods

- Metaheuristic approach which allows deterioration of the objective function to escape the local optimum
- Tabu search is a metaheuristic which enhances local search capabilities
- Recency based memory structure that stores recently visited solutions, so that they are not visited again, thus the name **Tabu**
- Iteratively moves from one solution ***x*** to an improved solution ***x'*** in the neighborhood of ***x***, ***N(x)***.
- Stops when the **termination criteria** is met, i.e., number of integer variables

Literature

Mohan Gopalakrishnan et al (2001) „A Tabu-Search Heuristic for the Capacitated Lot-Sizing Problem with Set-up Carryover "Management Science 2001 47:6, 851-863
Pedroso J.P. (2005) „Tabu Search for Mixed Integer Programming" Operations Research/Computer Science Interfaces Series, vol 30. Springer, Boston, MA.

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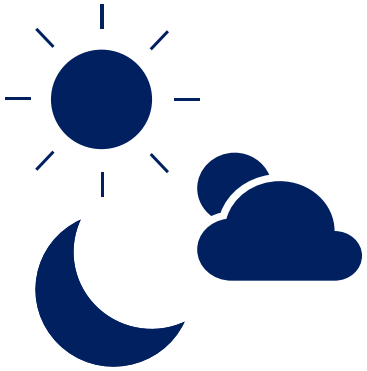
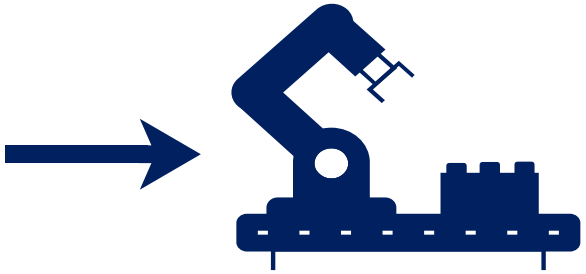
PROBLEM DESCRIPTION



Shifts

- **First Shift : 6am – 3pm**
- **Second Shift : 3pm – 12am**
- **Night Shift : 12am-6am**

22 parts

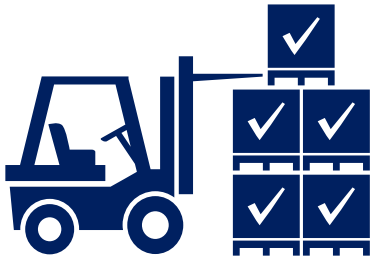


Injection Molding

7 machines

Parts

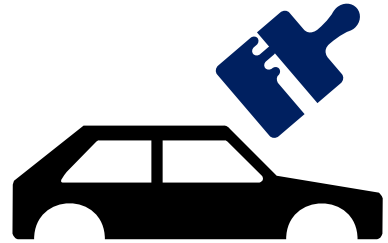
Empties



Intermediate Storage

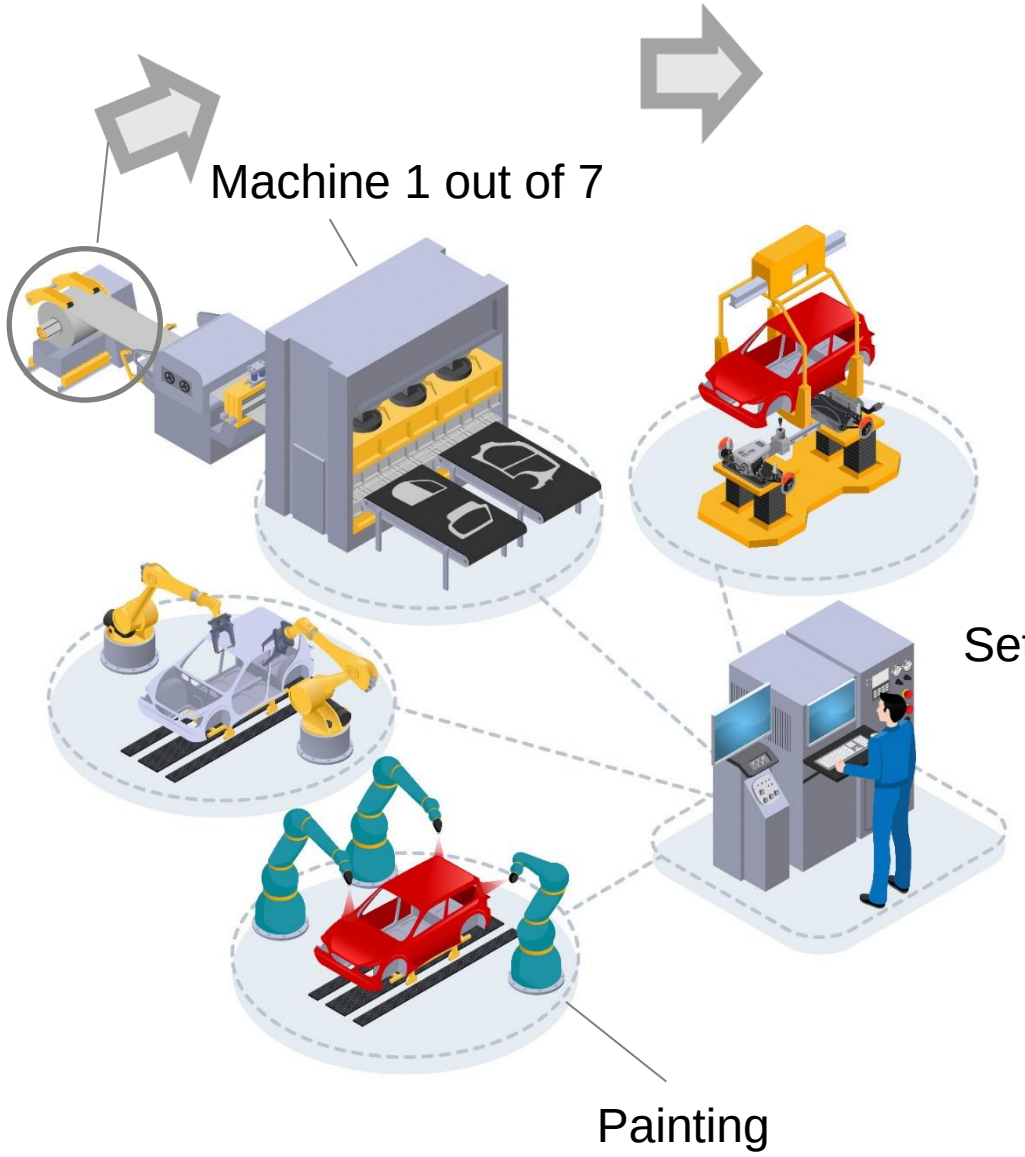
Parts

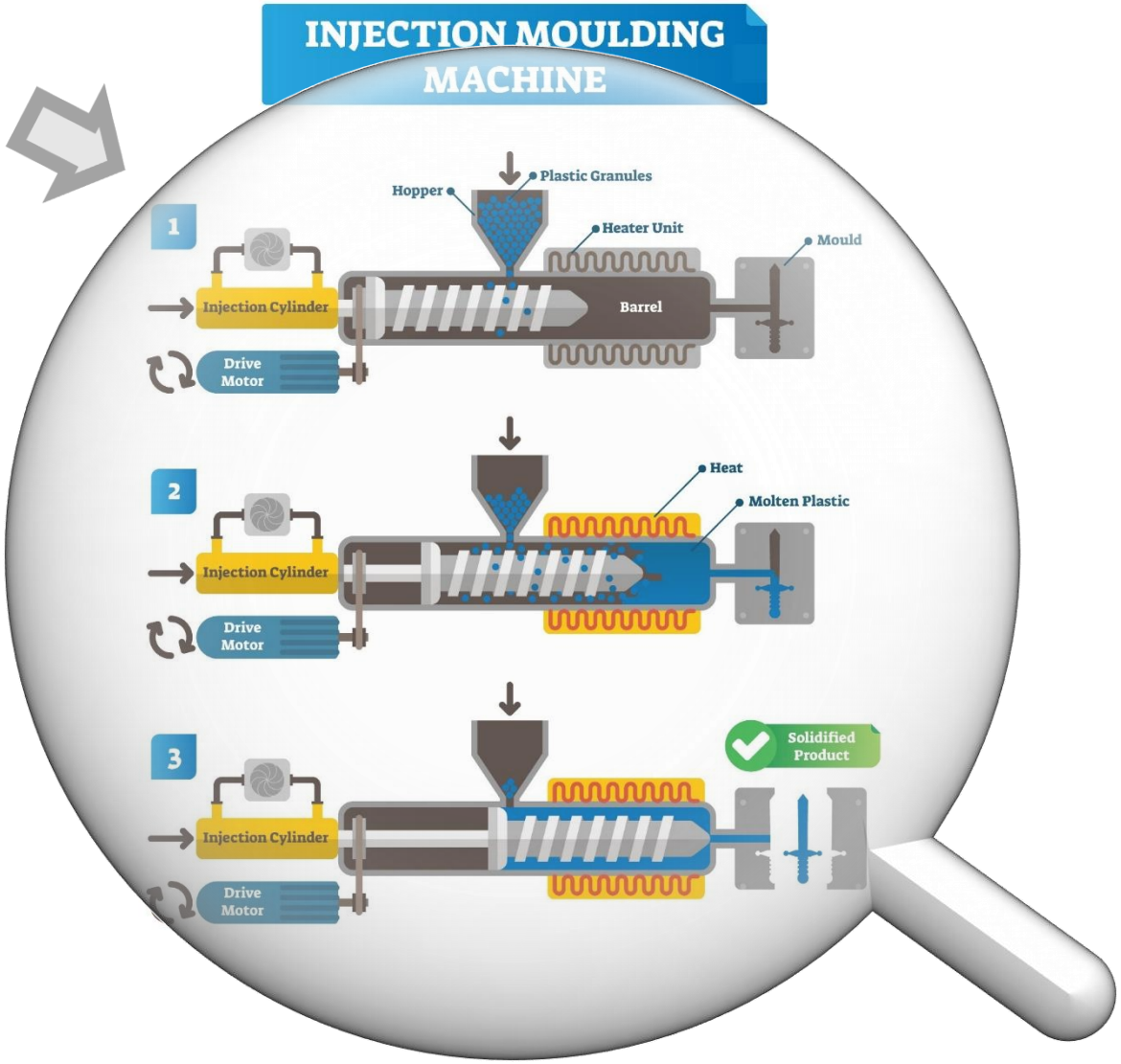
Empties



Paint Shop

PROCESS DESCRIPTION





OBJECTIVE

Objective 1

- Generate cost-efficient schedule
- Minimization of setup costs and inventory costs.

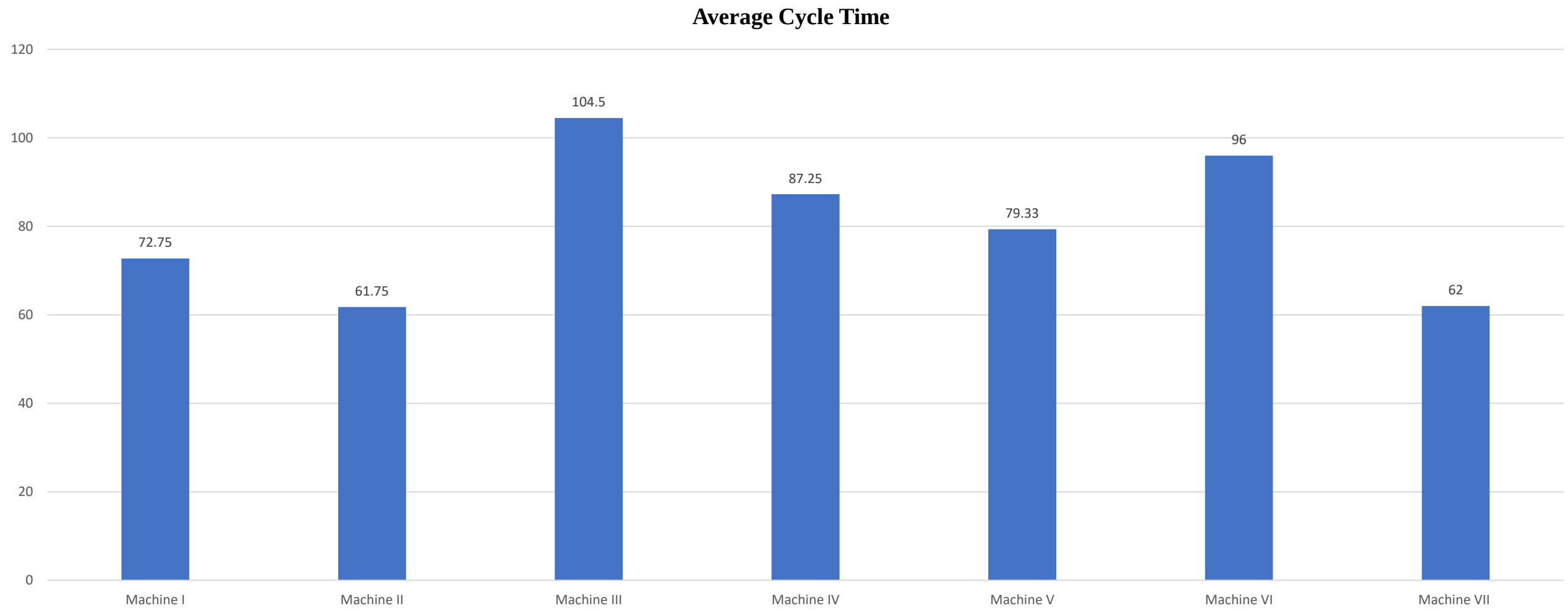
Objective 2

- Consider maximum number of available workers as restriction

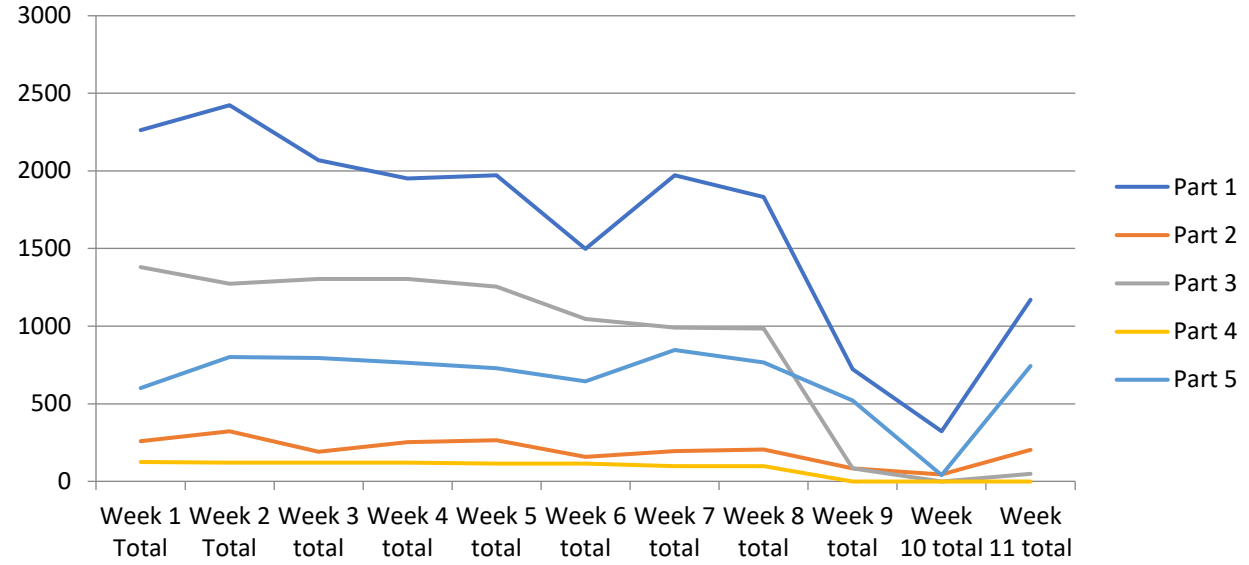
Objective 3

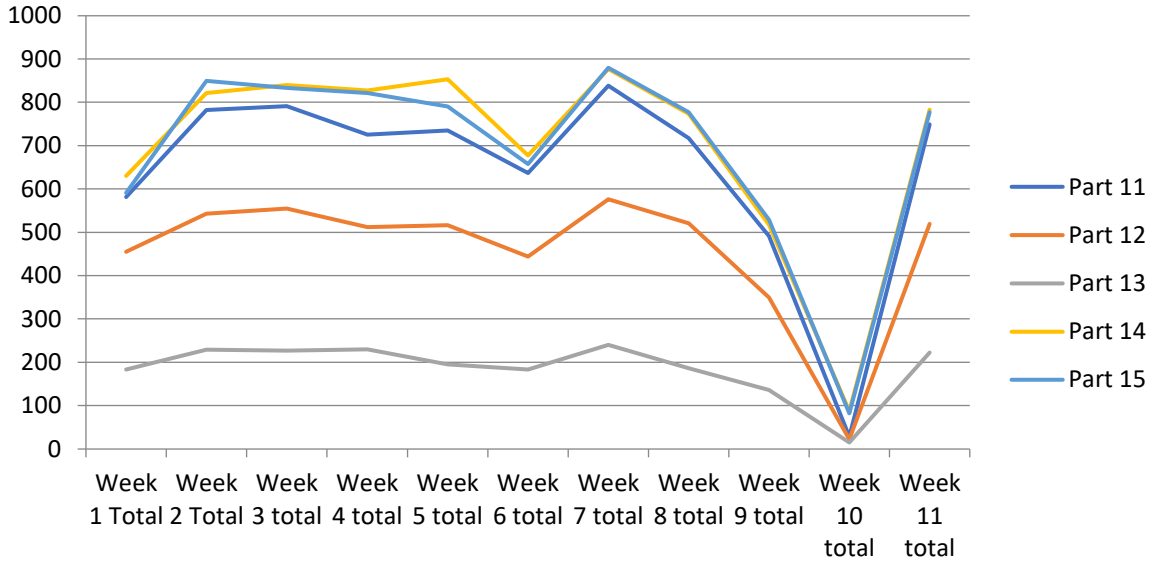
Analysis of the effects of varying number of workers.

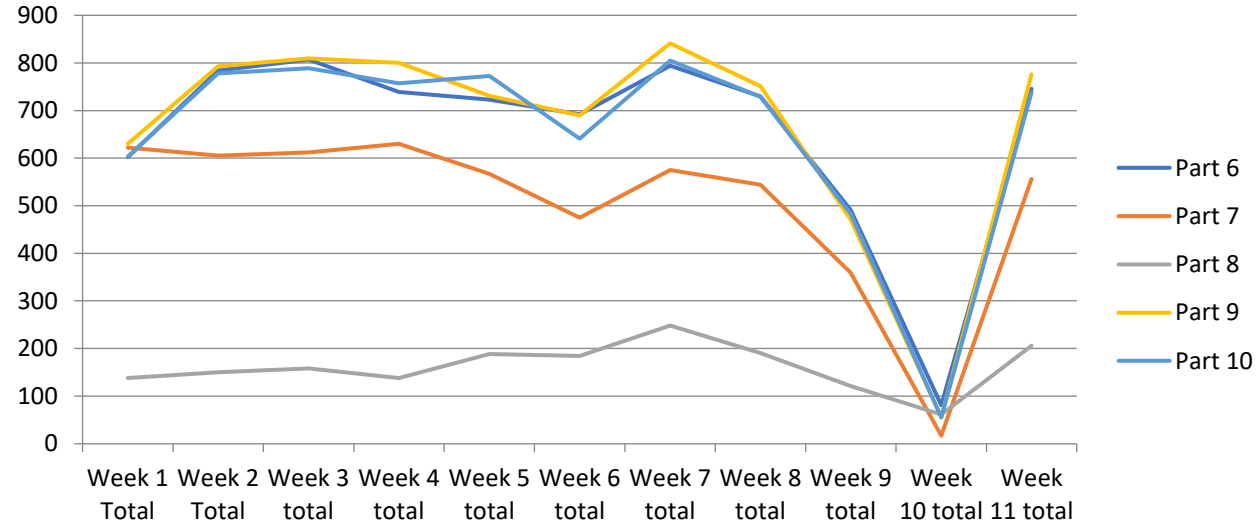
DATA VISUALISATION

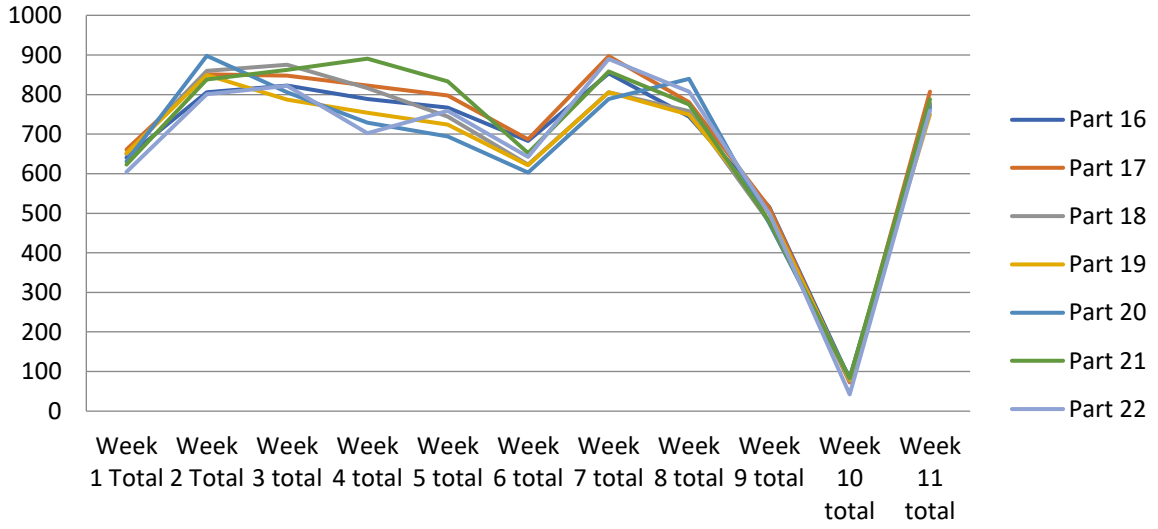


The graph above shows the average cycle time of each machine. Machine 3 is seen to have the highest cycle time.



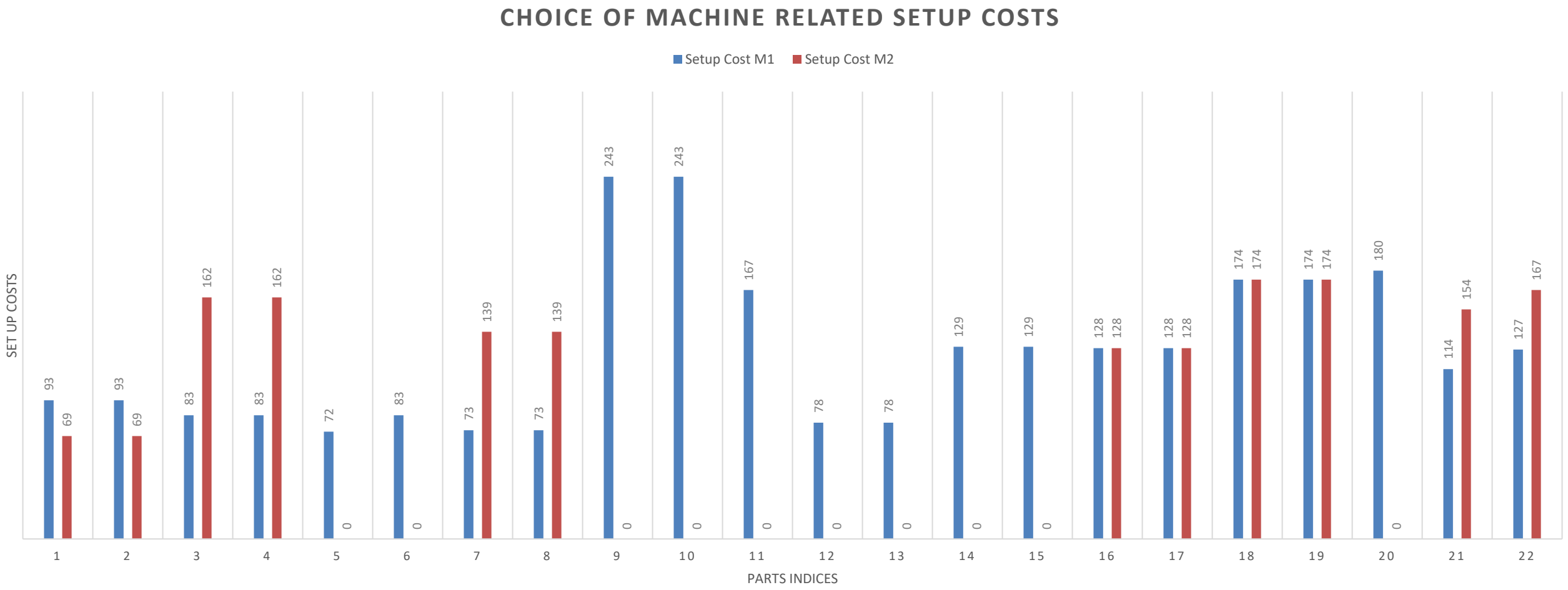




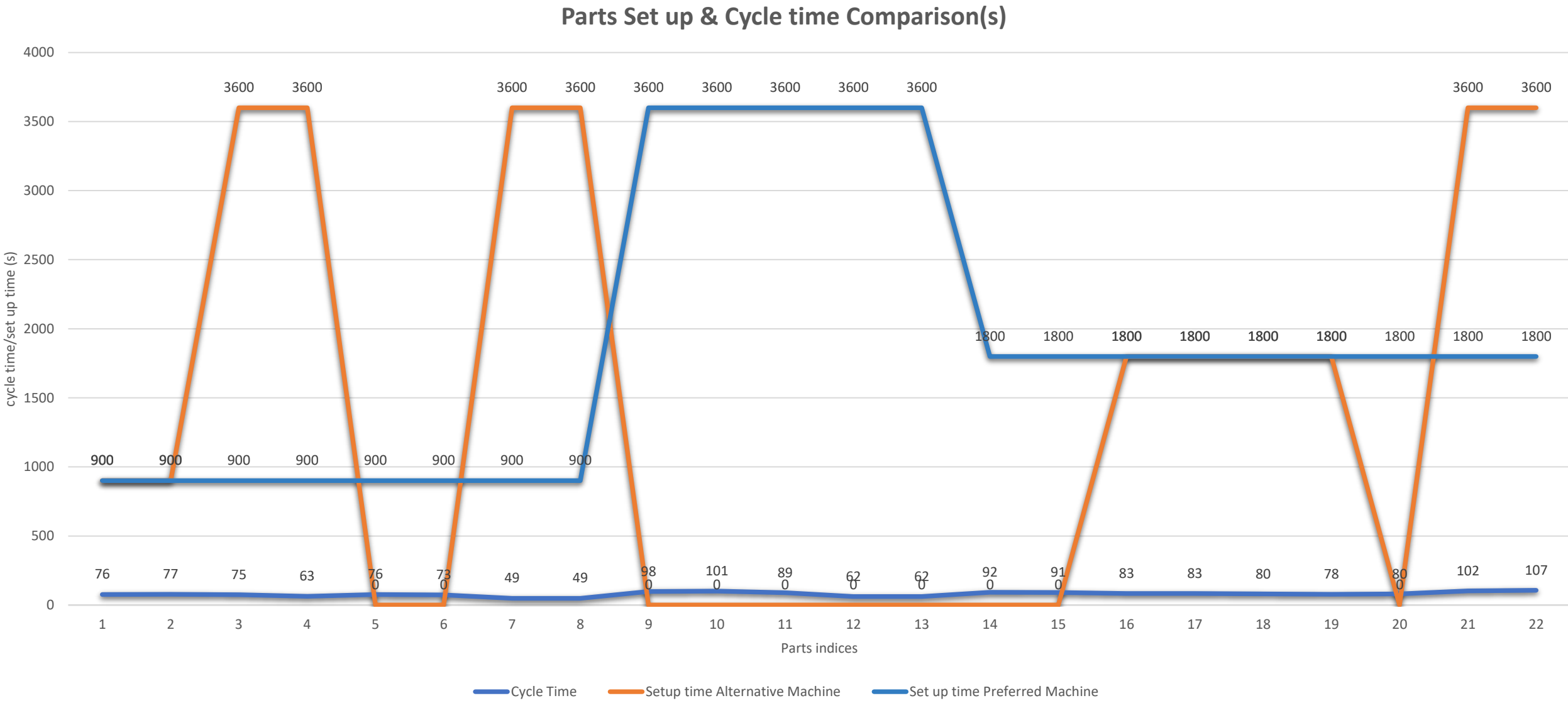


The two graphs display the trend of total demand of a parts 1 to 10 over the 11 weeks of data provided. It can be observed that most parts have a downward trend from week 7, while parts 2 and 4 have a steady demand across the weeks.

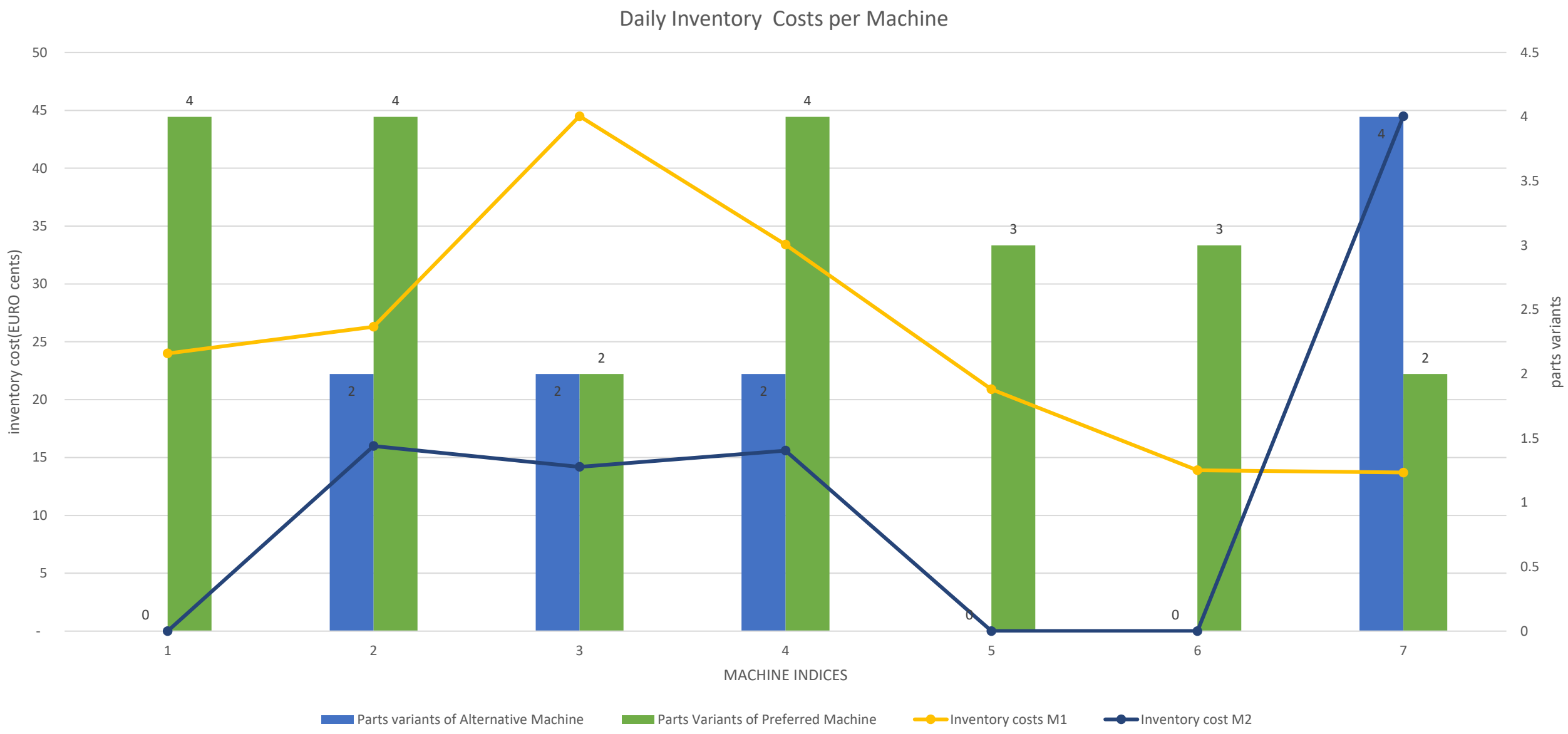
Data Visualisation



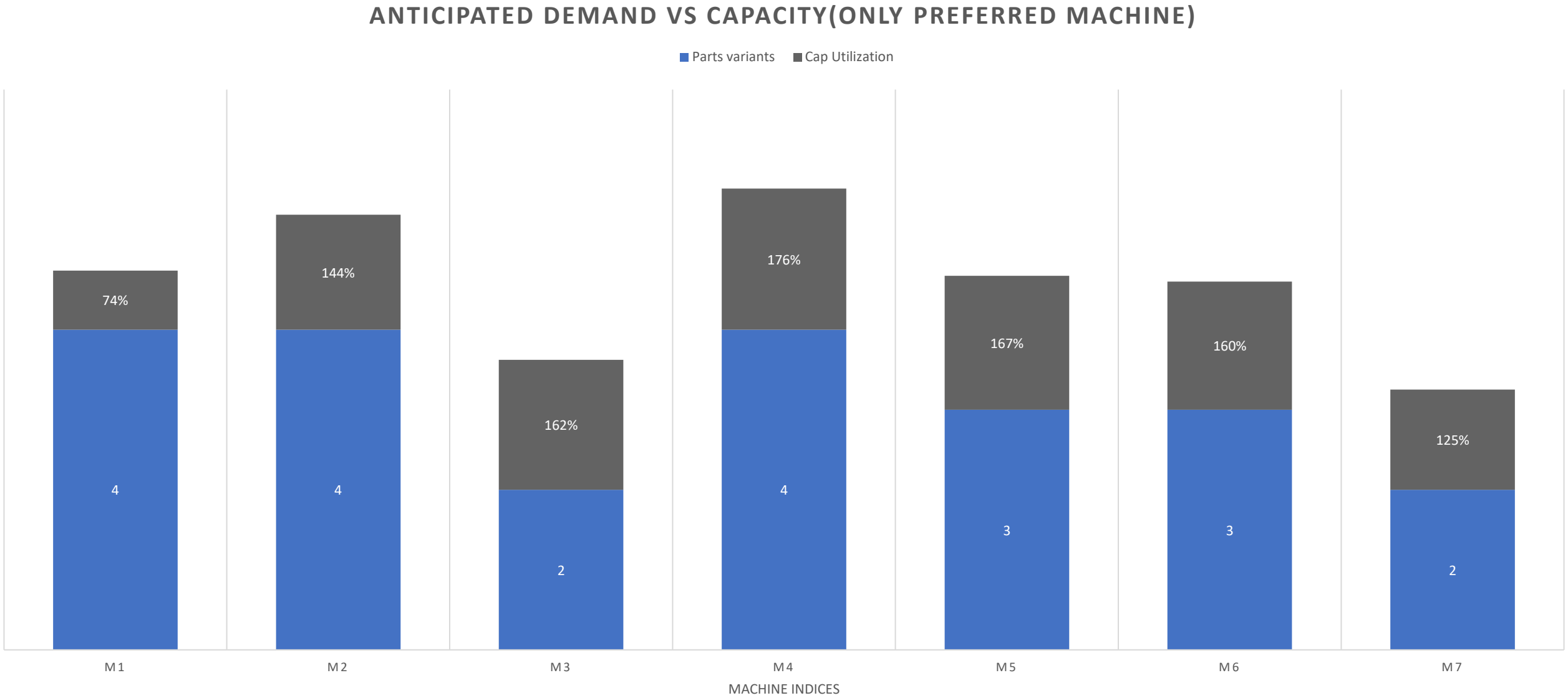
The graph depicts the Setup Costs for the Machine parts to be produced with both it's preferred machines.



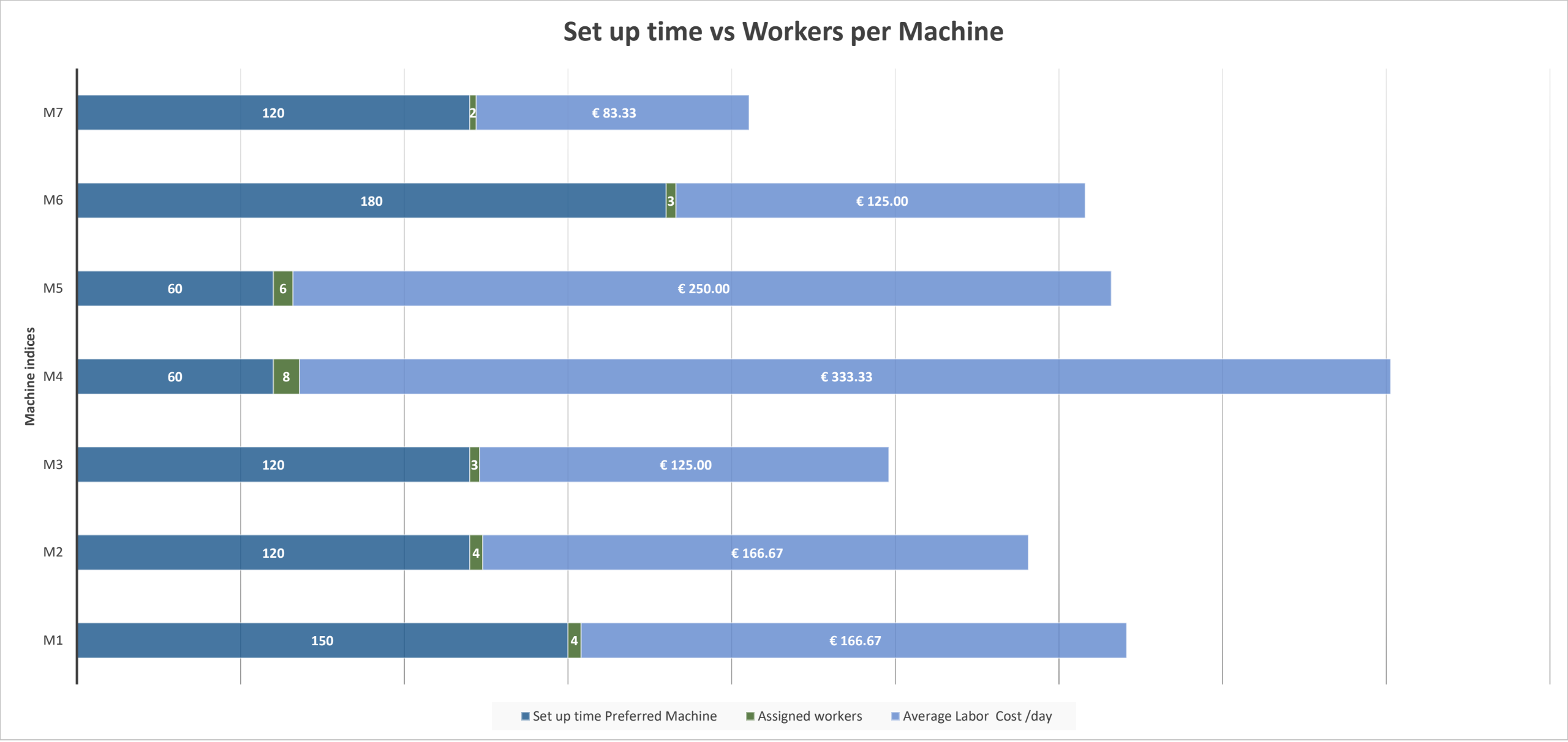
The graph shows the comparision of the Setup time and Cycle time each part takes to be produced.



The graph shows the Inventory Costs associated with the Preferred Machines and the Alternate Preferred Machines.

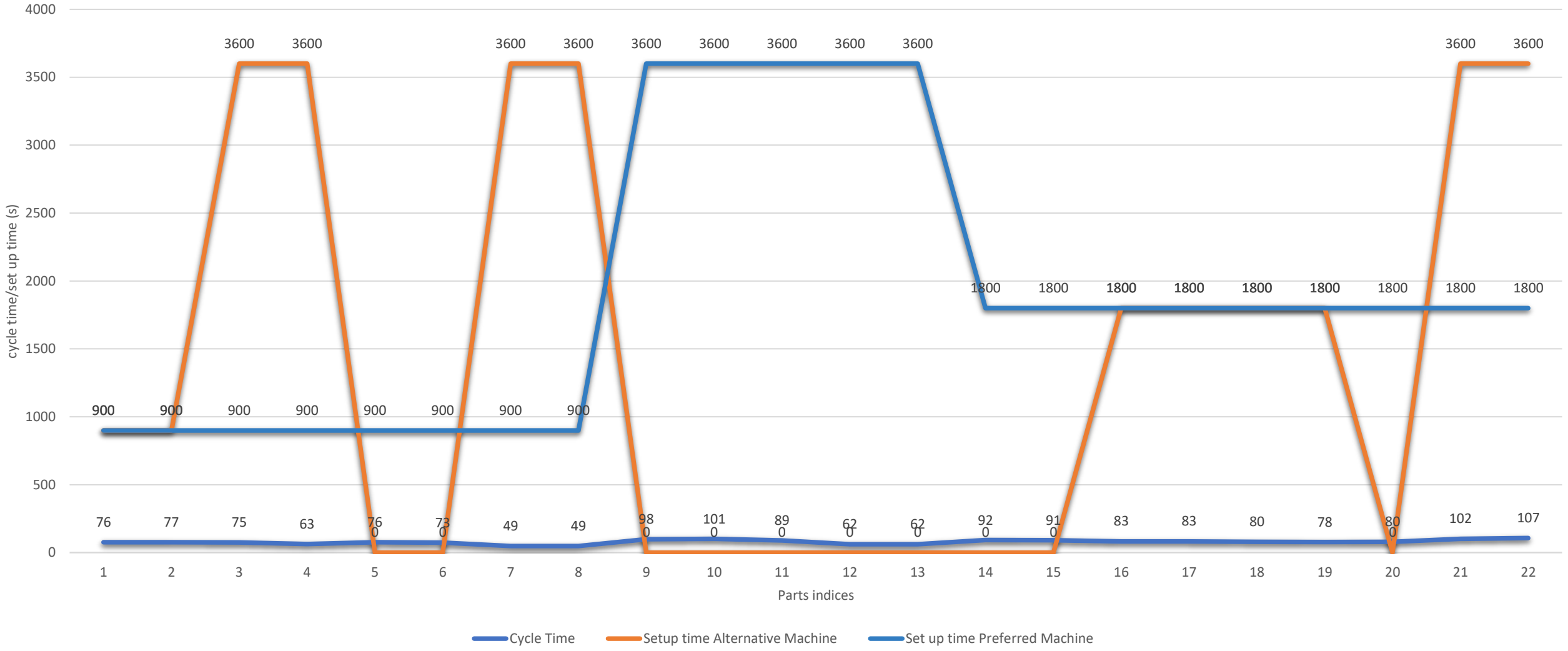


The graph depicts the Capacity utilization of the machines.



The graph shows the Setup time for each machine along with the assigned number of workers and the corresponding Average Labor Cost.

Parts Set up & Cycle time Comparison(s)



The graph shows the comparision of the Setup time and Cycle time each part takes to be produced.

SCHEDULE METHODOLOGY

1 **Weekly Data** →

- Weekly Data is obtained from Tabu Search
- It is received in the format shown below for every day of the week

(1,1,1),216

- This is in the format (Day, Machine Index, Part Index),Lot Size

2 **Excel Manipulations** →

- Using **Text to Column** function in excel to split the data for further use
- Set up Time, Inventory Time and Cycle time are obtained from the Raw Data File
- The data which is provided in seconds is then converted to hours and displayed in the hour format

3

Excel Calculations

- The start time for one part of every machine is considered as 6:00:00 am
- The Start Production value is calculated by adding set up times to initial time
- End Production time is calculated by adding Cycle time to Start Production time
- For the next part of a machine, the previous End Production becomes the new start of production time
- Total Cycle Time = (Lot Size*Cycle Time)/3600

Day	Machine Index	Part Index	Cycle Time(s)	Setup Time(hour)	Setup Time (Hour format)	Lot Size	Total Cycle Time (hours)	Total Cycle Time (Hour format)	Start Time	Start Production	End Production	Set Up Cost	Inventory Cost/Day
1	1	2	77	0.25	00:15:00	430	9.20	09:11:50	06:00:00	06:15:00	15:26:50	93	8.2
1	1	3	75	0.25	00:15:00	499	10.40	10:23:45	15:26:50	15:41:50	02:05:35	83	4

The table above shows a work in progress view of the steps mentioned above.

Sample Schedule

Day	Machine Index	Part	Lot Size	Start Time	Start Production	End Production
Monday	1	1	238	06:00:00	06:15:00	11:16:28
	2	6	69	08:21:40	08:36:40	10:00:37
	3	22	73	09:06:24	09:36:24	11:46:35
	4	15	78	08:49:32	09:19:32	11:17:50
	6	9	71	06:00:00	07:00:00	08:55:58
	6	10	71	09:23:44	10:23:44	12:23:15

RESULTS

Week 1

Set up Cost	Inventory Cost	Total Cost
10582	647.62	11229.62

Week 2

Set up Cost	Inventory Cost	Total Cost
9843	934.75	10777.75

Week 3

Set up Cost	Inventory Cost	Total Cost
13466	1253.63	14719.63

Week 4

Set up Cost	Inventory Cost	Total Cost
10702	978.05	11680.05

Week 5

Set up Cost	Inventory Cost	Total Cost
11102	779.31	11881.31

Week 6

Set up Cost	Inventory Cost	Total Cost
10628	622.78	11250.78

RESULTS

Week 7		
Set up Cost	**Inventory Cost**	**Total Cost**
13227	1281.39	14508.32

Week 8		
Set up Cost	**Inventory Cost**	**Total Cost**
13305	1156.52	14461.52

Week 9		
Set up Cost	**Inventory Cost**	**Total Cost**
10052	641.57	10693.57

Week 10		
Set up Cost	**Inventory Cost**	**Total Cost**
1135	**28.74**	**1163.74**

Week 11		
Set up Cost	**Inventory Cost**	**Total Cost**
12802	1060.26	13862.26

CONCLUSION

- Total inventory costs is 9384.62 Euros.
- Total setup costs is 116844 Euros.
- The knowledge about the Skill of the available workers is not known.
- The availability of the workers for the proposed schedule is considered to be constant.
- As an extension, Intensification and Diversification will be performed to check if a further improved solution can be obtained.
- Plan to try with a couple of different neighborhood structures.