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Academic Year

SIMULATION BASED PRODUCTION OPTIMIZATION AND PROCESS SCHEDULING

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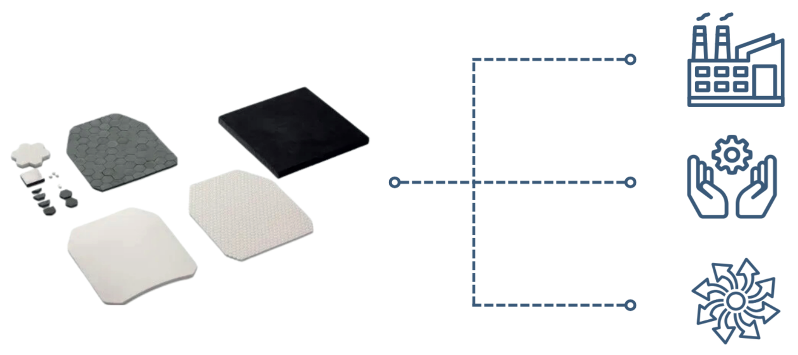
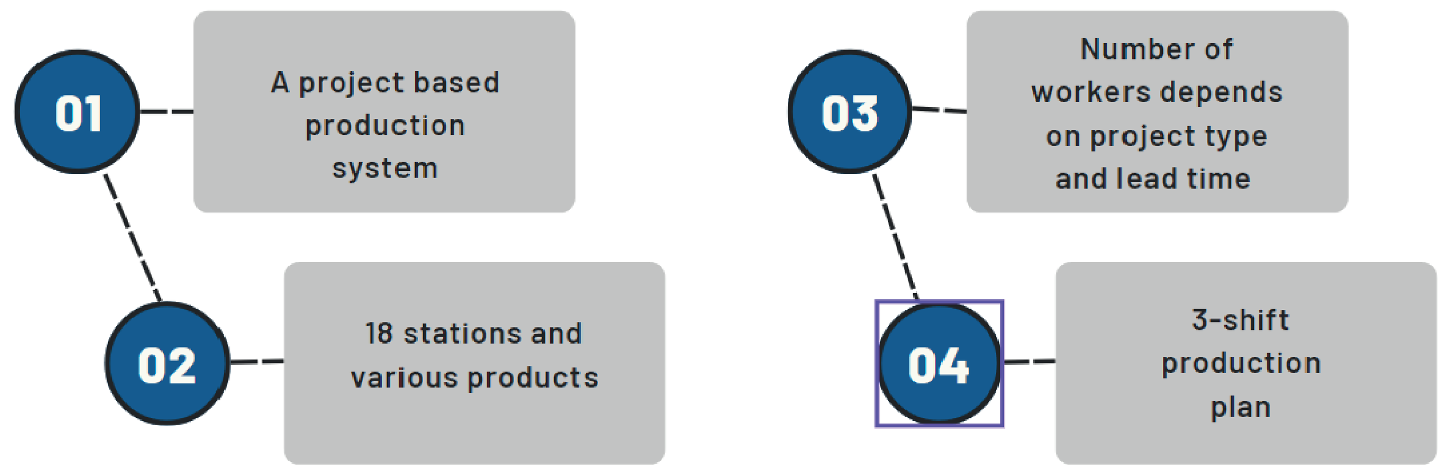
1 Introduction

KIM Technology has been established in 2019. They have emerged as a pioneering entity in the ever-evolving realm of advanced materials and technology. Their collective objective is to transform KIM Technologies into a global powerhouse, committed to manufacturing high value, advanced materials for various applications



2 System Under Consideration



3 Problem Definition

One of the company's main problems is machine efficiency issues, which is further complicated by uncertain downtimes and the inability to accurately determine the production capacities of the machines. Inadequate data collection on the capacity and performance of machines leads to inefficient labor management. The project-based production methodology applied by the company increases the complexity of the processes, making the scheduling of production even more demanding due to the uniqueness and varying requirements of different projects. To overcome these challenges and make production processes more efficient, KIM Technologies needs to collect and analyse production data, better standardize its processes, and develop flexible and dynamic production planning systems that can meet complex project based production needs more effectively.

4 Objectives Of Project

The project aims to increase production efficiency and process optimization at KIM Technologies. To this end, a comprehensive improvement process is planned using production scheduling and simulation techniques. The main objectives of the project a re as follows:

Optimizing Production Flows with Production Scheduling: Using the developed mathematical model and interface, production processes will be organized more efficiently so that products can be delivered to customers on time.

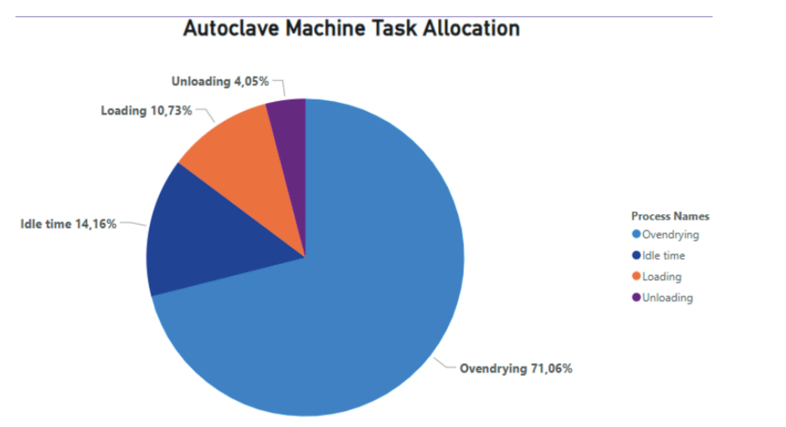
Analysis of Production Processes with Simulation Techniques: Simulation techniques will be used to analyze existing production processes in detail and identify potential bottlenecks as well as factors that lead to inefficiencies such as machine downtime.

Contribution of Simulation Results to the Improvement of Operational Processes: Simulation results provide valuable information for the improvement of operational processes.

5 Methodology

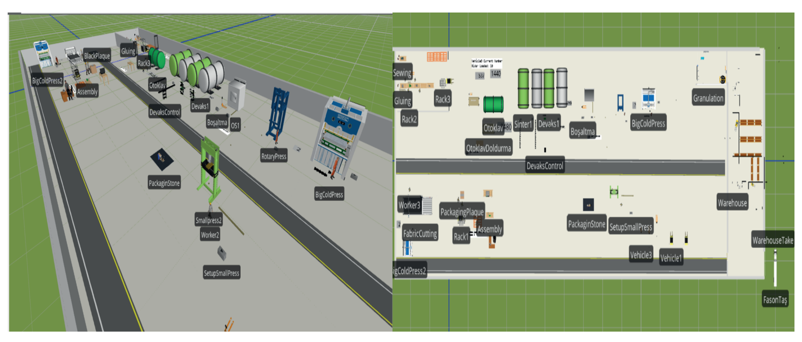
1.Process Analysis

Using time study, the operation of machines and stations was examined



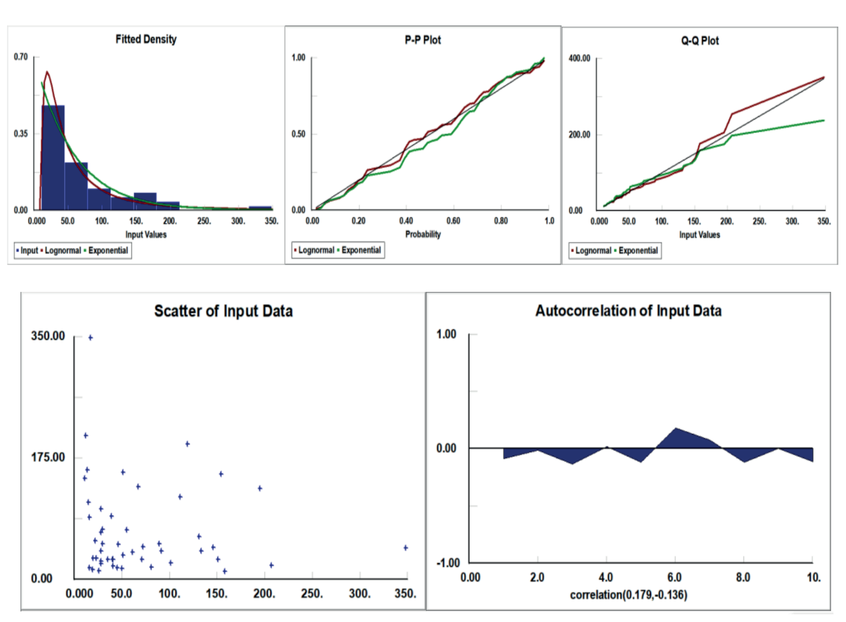
2.Simulation Model

Simulation is one of the best tools for analysing the systems. Especially in the system that need some investment to change something, like production systems.



3.Input Analysis

Based on time study inputs, the probability distribution of each station was determined by using Statfit software



4.Output Analysis

If the machines working with too much utilization, it means that products waiting in line to enter station. Basically, the bottleneck of the system is these stations. On the table, it can be seen that Assembly, stone stacking and autoclave machines have high utilizations.

Server	Utilization	Server	Utilization
Sinter1	22.20%	Assembly	100.00%
FabricCutting	17.10%	Autoclave	100.00%
Sinter2	16.40%	StoneStacking	100.00%
OS1	13.30%	AutoclaveLoading	78.60%
AutoclaveUnloading	12.80%	Sewing	65.40%
DevaksControl	10.80%	RotaryPress	40.20%
Devaks2	10.30%	PackaginStone	35.40%
RubberBanding	8.59%	BigColdPress	33.40%
Gluing	5.40%	BigColdPress2	32.90%
RubberRemoval	3.77%	Devaks1	29.20%
PackagingPlaque	1.60%	Qcontrol	22.60%

5 Mathematical Model

This model establishes a production scheduling plan for the optimization of production processes at KIM Technology.
The objective of the model is to maximize production efficiency by minimizing the total completion time

Indices:

i: stations (i= 1…18)
j: products (j=1…14)
k: position (k=1…18)

Parameters:

P_{ji} : Total processing time of the product j on station i

Decision Variables:

X_{jk}: If product j is assigned to position k, 1; otherwise, 0.
S_{ki}: Start time of the product at position k at station i
C_{ki}: Completion time of the product at position k at station i
C_{max}: Total completion time

Objective Function:

Min Z = C_{max} The purpose of the model is to minimize the total completion time. This aims to reduce delays in the overall production process and thus speed up delivery times.

Constraints:

1. $C_{max} \geq C_{KM}$ $\forall$ k = K , $\forall$ i = M C_{max} value must be greater than or equal to the completion time of the last product processed at the last workstation. This refers to the completion time of the entire production process.
2. $\sum_{j=1}^{j=14} X_{jk} = 1$ $\forall$ k Each product must be assigned to a position.
3. $\sum_{k=1}^{k=18} X_{jk} = 1$ $\forall$ j Each product must be processed.
4. $C_{ki} = S_{ki} + \sum_{j=1}^{j=14} X_{jk} * P_{ji}$ $\forall$ k, i Calculation of the completion time.
5. $C_{ki} \geq C_{(k-1)i} + \sum_{j=1}^{j=14} X_{jk} * P_{ji}$ $\forall$ k, i The kth product of station i can only start when the product at the previous position is finished.
6. $C_{ki} \geq C_{k(i-1)} + \sum_{j=1}^{j=14} X_{jk} * P_{ji}$ $\forall$ k, i $i \neq 1$ The kth product of station i can only start when the job at the previous station is finished.
7. $C_{11} \geq \sum_{j=1}^{j=14} X_{j1} * P_{j1}$ Completion time of the product at the first position at the first station.
8. $S_{ki} = C_{ki} - \sum_{j=1}^{j=14} X_{jk} * P_{ji}$ $\forall$ i, k Start time of the kth product at the station i.
9. $S_{11} = 0$ The start time of the product at the first position at the first station will be 0.
10. $S_{ki} \geq C_{(k-1)i}$ $\forall$ i, k $k \neq 1$ The start time of the product at the kth position at the station i is greater than or equal to the completion time of the previous product at station i.
11. $S_{ki} = C_{k(i-1)}$ $\forall$ i, k $i \neq 1$ The start time of the product at the kth position at station i is equal to the completion time of the the same product at the previous station.
12. $C_{k1} \geq C_{(k-1)1} + \sum_{j=1}^{j=14} X_{jk} * P_{j1}$ $\forall$ k, $k \neq 1$ Completion time of the products to be processed in the first station
13. S_{ki} , C_{ki} , C_{max} ≥ 0 $\forall$ i, k Nonnegativity constraints
14. $X_{jk} \in \{0,1\}$ $\forall$ j, k Indicates binary variable

6 Results

1.Gams Results

The model was run with GAMS software. The figure below shows the results of the decision variable X(j,k) . The meaning of this decision variable shows to which position k product j is assigned. The production sequence will be 11,13,6,8,4,7,5,9,1,3,10,2,12,14.

GAMS RESULT	
MIP Solution	40620
Best possible	40620
Absolute gap	0
Relative gap	0,00%

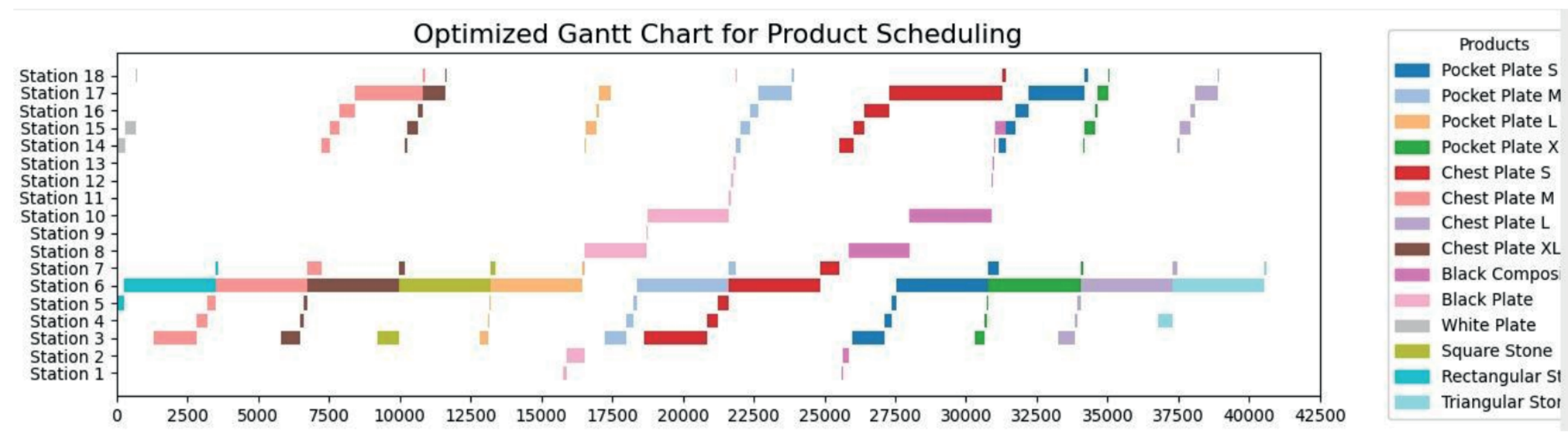
	POSITION													
Product	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1									1					
2												1		
3										1				
4					1									
5							1							
6			1											
7						1								
8				1										
9								1						
10											1			
11	1													
12													1	
13		1												
14														1

The next figures show the value of the decision variables S(k,i) and C(k,i) . The decision variables S(k,i) and C(k,i) represent the start and end times respectively.

Product	Start Time (day)	Completion Time (day)
11	0,0	0,5
13	0,0	2,5
6	0,9	7,6
8	4,0	8,1
4	6,6	9,9
7	8,6	12,6
5	9,3	18,2
9	14,2	18,2
1	14,5	20,2
3	17,5	20,7
10	19,6	23,9
2	20,6	25,2
12	23,6	26,0
14	25,5	28,2

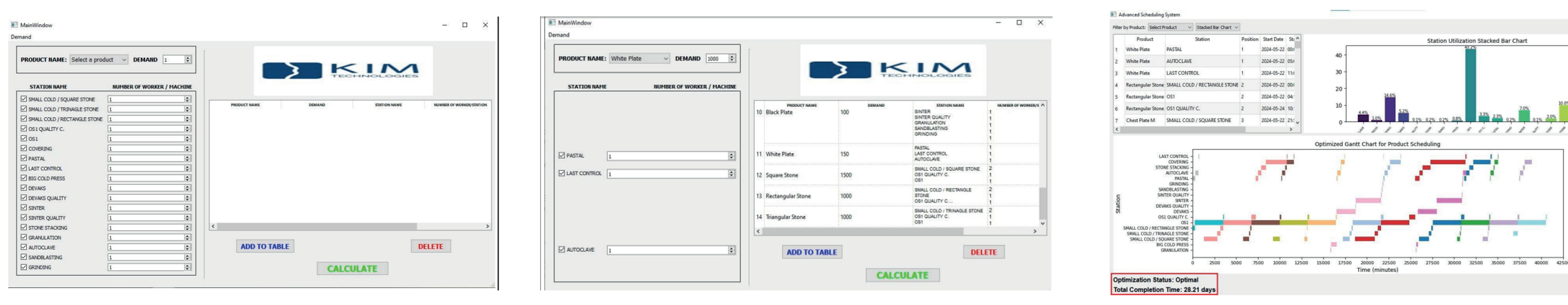
Product	Start Time (minutes)	Completion Time (minutes)
11	0	735
13	0	3590
6	1315	10885
8	5780	11635
4	9507,5	14237,5
7	12435	18090
5	13450	26225
9	20450	26240
1	20822,5	29147,5
3	25237,5	29877,5
10	28205	34345
2	29675	36342,5
12	33920	37430
14	36780	40620

Gannt chart of production scheduling was created at Phyton.



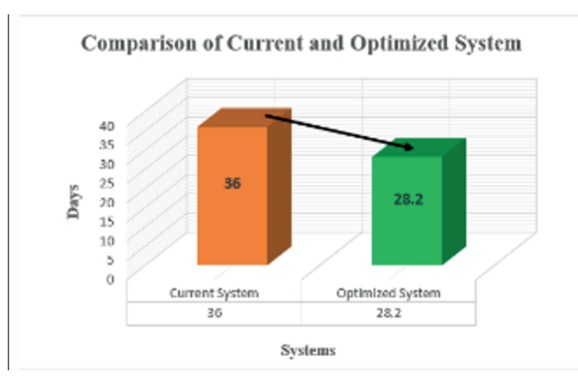
2. Scheduling Interface

An interface has been designed where users can select the product and station for scheduling. Optimized scheduling system based on the requested product demand and the number of machines/workers to be used. When clicking on the "calculate" button, the program gives us the optimal scheduled plan for production in advance.

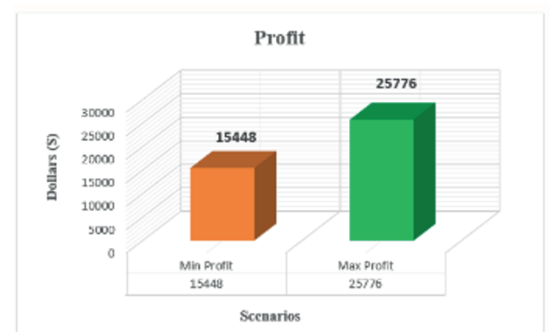


7 Project Outcomes

Demand data used in the problem covered approximately 6 weeks.
36 days was reduced to 28.2 days.
It means a reduction of 7.8 days, 21.67% improvement.



It was first calculated roughly how much of each product could be produced per day
It was calculated that 1352 products could be produced in 7.8 days
These products could bring a profit of $15448 - $25776 to the company.



8 Conclusion

Our project presents a thorough analysis and enhancement of KIM Technologies' production system. The current situation was scientifically examined through process analysis and simulation modeling. A mathematical model was initially executed in GAMS and then transformed into Python code using the PuLP library to design the interface. Our project demonstrated a comprehensive approach to production optimzation, combining theoretical modeling with practical application, and resulting in operational improvements and financial benefits for the company.

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