Mühendislik Bilimleri ve Tasarım Dergisi
11(1), 22 – 32, 2023
e-ISSN: 1308-6693

Journal of Engineering Sciences and Design
DOI: 10.21923/jesd.1101063

Araştırma Makalesi | Research Article

A PRODUCTION LINE ASSIGNMENT PROBLEM FOR A TEXTILE INDUSTRY

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Keywords

Assignment Problem, Mixed-Integer-Linear Programming, Production Line, Textile Industry, Production Planning.

Abstract

In this study, the production process of Karaman Textiles, for which production planning is done manually, was observed and analyzed. This study aims to minimize the unused machine capacity and idle time of the existing system by developing a mixed integer programming (MIP) model, developing scenarios, and obtaining the results with GAMS software. In addition, the results of the scenarios are compared and evaluated to reach the optimal result that meets and maximizes the efficiency of the production process. The company's usual production planning is done manually and determined according to annual demand. The study aims to minimize the machine working times and that complete planning of the production in the most optimal way. In this study, the company's production time and machine usage times were optimized, and under normal conditions, 15,000 fabric pants were produced for 8 hours a day, 5 days a week, and 4 weeks a month. The scenario analysis aimed to produce by adding 4,000 pieces of velvet pants in addition to 15,000 fabric pants in the first scenario. The second scenario aims to minimize the production time of 15,000 fabric pants by limiting the working times of the machines owned by the company.

BİR TEKSTİL ŞİRKETİ İÇİN ÜRETİM HATTI ATAMA PROBLEMİ

Anahtar Kelimeler

Atama Problemi, Karışık Tam Sayılı Doğrusal Programlama, Üretim Hattı, Tekstil Endüstris, Üretim Planlama.

Öz

Bu çalışmada, üretim planlaması elle yapılan Karaman Tekstil'in üretim süreci gözlemlenmiş ve analiz edilmiştir. Bu çalışma, bir karma tamsayılı programlama modeliyle, senaryolar geliştirerek ve sonuçları GAMS yazılımı ile elde ederek mevcut sistemin kullanılmayan makine kapasitesini ve boşta kalma süresini en aza indirmeyi amaçlamaktadır. Ayrıca, üretim sürecinin verimliliğini karşılayan ve maksimize eden optimal sonuca ulaşmak için senaryoların sonuçları karşılaştırılmakta ve değerlendirilmektedir. Şirketin olağan üretim planlaması elle yapılmakta ve yıllık talebe göre belirlenmektedir. Çalışma, makine çalışma sürelerinin en aza indirilmesini ve üretim planlamasının optimal şekilde tamamlanmasını amaçlamaktadır. Bu çalışmada, firmanın üretim süresi ve makine kullanım süreleri optimize edilmiş olup, normal şartlar altında, günde 8 saat, haftada 5 gün ve ayda 4 hafta olmak üzere 15.000 kumaş pantolon üretilmiştir. Senaryo analizi, ilk senaryoda 15.000 adet kumaş pantolona ek olarak 4.000 adet kadife pantolon eklenerek üretilmesi hedeflenmiştir. İkinci senaryoda ise şirkete ait makinelerin çalışma sürelerinin sınırlandırılarak 15.000 kumaş pantolon üretim süresinin en aza indirilmesi planlanmıştır.

Alıntı / Cite

Abdelsalam, N., Mohammoud, F., Eder, H., Abuyoussef, A., W., E., Kaya, Ö., Kilic, A., C., Ulku, I., (2023). A Production Line Assignment Problem for a Textile Industry, Journal of Engineering Sciences and Design, 11(1), 22-32.

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Makale Süreci / Article Process	
Başvuru Tarihi / Submission Date	11.04.2022
Revizyon Tarihi / Revision Date	12.10.2022
Kabul Tarihi / Accepted Date	12.12.2022
Yayım Tarihi / Published Date	27.03.2023

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A PRODUCTION LINE ASSIGNMENT PROBLEM FOR A TEXTILE INDUSTRY

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Highlights

- This study aims to minimize the unused machine capacity and idle time of the existing system by developing a mixed integer programming (MIP) model. Several scenarios are developed. The results are obtained with the GAMS software. Also, the results are compared and evaluated to reach the optimal result that maximizes the efficiency of the production process. The process of making pants passes through 5 essential stages and the demand is 15,000 pants to be completed in 30 days. The model worked on minimizing the unused machine capacity by converting the specified demand into time.
- This study also minimizes the machine working times and complete planning of the production in the optimal way. The real data is obtained in order to use the company's production time and machine usage times and then it is optimized.
  The scenario analysis aimed to produce by adding 4,000 pieces of velvet pants in addition to 15,000 fabric pants in the first scenario. The second scenario aims to minimize the production time of 15,000 fabric pants by limiting the working times of the machines owned by the company.
- To ensure continuous growth and success by meeting demands and customer satisfaction, it is recommended to do further studies that focus on the other weak points of the company.

Purpose and Scope

In this study, the production process of a textiles industry is observed where the production planning is performed manually. Thus, with this study, minimizing the unused machine capacity and idle time of the existing system is the main motivation of the research.

Design/methodology/approach

A mixed integer programming (MIP) model is developed which minimizes the total unused capacity. With the objective function, there are several constraints in order to solve the exact problem. First of all, each job must be assigned to a machine, the number of machines must be balanced with the capacities, the total assigned jobs must be less than and equal to the number of required machines.

Findings

The results of the MIP model and GAMS software are analyzed and compared with different scenarios. The total monthly working hour is 302,400 seconds, and 12 out of 14 machines are used. The capacity of the 14 machines was calculated as 4,233,600. In the suggested scenario, the wasted time was decreased so the company became using 12 machines and used 73.92% of the machine time instead of 51.75% in their normal conditions. This scenario would increase work efficiency by minimizing the working time of producing the product which will lead to the ability to meet the demand in the needed time and even being able to increase it.

Research limitations/implications (if applicable)

The company is planning to expand opening a new branch and increasing its production capacity. It is essential to pick the right location for the new branch, decide on the number of machines and workforce needed, and determine if the new branch would include a warehouse for the finished products or not, so future studies could include a studied decision about the new branch of the company.

Practical implications (if applicable)

In this paper, a textiles industry's production process is observed where the production planning is performed manually. Therefore, the proposed model focuses on minimizing the unused machine capacity by converting the specified demand into time. In this study, two scenarios were suggested where both could positively impact the company's performance. In the first scenario, jobs were examined, and the number of machines used was calculated. This scenario leads to a decrease in the unused machine capacities and minimized the lead time. In the second scenario, decreasing working hours to 7 hours and working days to 3 days were the main targets. The wasted time was decreased so the company became using 12 machines with a capacity of 73.92% of the machine time instead of 51.75% in their current conditions.

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Social Implications (if applicable)

The capacity of their current resources are used efficiently, thus with this paper climate and environmental issues are improved in terms of carbon emissions whicg is a crucial factor for the production industries.

Originality

In this study, the production process of a textiles industry is observed where the production planning is performed manually. Thus, with this study, a real data is used in order to minimizing the unused machine capacity and idle time of a real existing system. Therefore, the results can be applied and the efficiency of the proposed model can be used as a regular production planning process for any production industry.

1. Introduction

Industries are a crucial part of the economy of any country because it is responsible for the conversion and processing of raw materials into finished products that cover the needs of the society and as a result of globalization, a huge trading network where all kinds of goods are exchanged, generating the movement of money around the world. Industrial production and manufacturing are the most essential sector in Turkey. Manufacturing refers for nearly 85 percent of the total production and the top five segments in Turkey are gradually among the biggest: food production which represents 16% of total production, metals 11%, motor vehicles and trailers 9%, textile 8%, and non-metallic mineral products 6% (TÜİK, 2021). Considering the textile production in the world, Turkey is among the world's leading textile and clothing producers and the world's sixth-largest supplier, and the EU's third-largest supplier. By the IGEA (Istanbul Garment Exporters Association), the sector accounted for 10.1 percent of the country's overall exports of $14.8 billion in January 2020, with $1.5 billion in exports, up 5.8% from the same month the previous year. In addition to that, the sector is important as more than one million people work in Turkey's textile and ready-to-wear industries. This number is expected to rise in the next years because of increased investments and exports (TÜİK, 2020).

In this highly competitive market, companies must plan their production properly to meet the demand on time, employ fewer workers and machines, avoid overtime, and maintain high customer satisfaction. Subsequently, these factors will turn the company into a leading company in its sector and help in further expansion in less time. Among the textile companies in Turkey, this paper will be focusing on the Karaman Textile Company, which was founded in 1994 and is located in Istanbul. The company produces mainly pants with a monthly output of 2,600 pants and a demand of 35,000 pants yearly. The company is facing some issues that would affect its products and affect its income adversely. These problems include mainly the delay in the completion of the production, besides the lack of expertise in expecting and determining the time when the job leaves the system, and the inability on meeting the demand. Subsequently, this study aims at finding solutions for the issues facing the company besides studying the production system and suggesting better production schedules. In addition to that, the study will propose a recruitment process for more experienced employees and will help in optimizing production by minimizing the idle time of laborers and machines and finding out the optimal number of machines needed to increase productivity and meet the demand. The remaining part of this paper is as follows: the literature review is given in section 2. The proposed mathematical model is represented in detail in section 3. Section 4 gives brief information about the methodology and the implementation and results are represented in Section 5. The Paper concludes with a conclusion in Section 6.

2. Literature Survey

In the previous studies, various production configurations were examined. A model was tested by using a discrete-event simulation model in a clothing company and the study aims at improving the manufacturing process. Results indicate that the independent factors affect the production size in different dimensions (Bevilacqua et al., 2013). Besides that, another study aimed to reduce cycle time for several workstations by prioritizing the constraints of resources, resource types, and precedence relations. The study proposed an assembly line stabilizing for this intricate clothing assembly line. Arena simulations software was used to perform a discrete event simulation of the trouser assembly (Bongomin et al., 2020). Some studies revised the production line architectures by mixing and integrating two different lines and improved production efficiency, reducing production costs (Zhao et al., 2022). A review study for assembling line balance problems advised using decision support software and experienced planners to reduce planning time and effort (Boysen et al., 2022). Another study focused on personalized product production systems' assembly line optimization, and they applied two-step multi-manned assembly lines for customized manufacturing and achieved a utilization rate of more than 90% (Pilati et al., 2022).
If the problem is considered as a linear programming model, a study related to the assignment of semiconductor wafers to consumer orders, an objective function defined as to minimize the cumulative overallocation. The

constraints such as that all clients' demands are covered, and that a wafer cannot be assigned to more than one order are given (Deenen et al., 2020). In another study, a MIP model was developed to reduce the total delay of customer orders. The objective is to determine the starting time of dying and weaving to minimize the total tardiness of the sequence. Constraints such as each task having only a prior and one successor task, and in both the weaving and dyeing stages, each task must be assigned to only one task each task has only one prior task, and one successor task is determined (Hsu et al., 2009). In another assignment problem, it is determined that tasks can be assigned to one batch and one machine while ensuring that all tasks can be finished before their deadlines. The study aims to create a multi-subpopulation genetic algorithm that minimizes the completion time of jobs and the make-span to improve the textile batch coloring schedule. Constraints ensure that every single batch belongs to a single group and that only jobs in the same group can be batched together and guarantee that the batch capacity does not exceed the determined capacity (Huynh and Chien, 2018). If the objective becomes minimizing both cycle time and maximum physical labor of the workstations, constraints could be considered as each task is delegated to only one workstation, and each employee is assigned only one workstation (Katiraee et al., 2021).

A study conducted in another textile company has four production patterns that produce pants that targeted the best fit for customers and developed an optimum pattern. The key finding of the study is that there is a need for further studies on optimum body shapes and sizes to produce effectively and more focus on the development of trouser-making patterns (Kim et al., 2020). Another study aims to create an optimal parallel machine schedule that minimizes the total delay and they used constraints such as the total amount of sub-tasks of a task processed on different machines being equal to the size of the task, the number of sub-tasks of a task on a machine is equal to zero if the task is not processed on the machine, and ensuring a task is properly linked to a machine (Lim and Cassidy, 2017). Another linear programming example that used the MIP model aims to minimize the make-span of the cutting process in a manufacturing system. The constraints in that study determined such as the make-span of the cutting process in a manufacturing system and determined such as the make-span of the schedule should exceed the completion time of each fabric layer, and if the fabric layer is chopped on the table the farther end of the fabric lay should be on the inside of the cutting table (Wang et al., 2016).

Also, in some studies, the lengthy production lead time and low throughput were addressed, and computer simulation was used to determine the optimal solution to increase productivity. The performance of the existing sewing line was modeled by Arena Software and the collected data were statistically analyzed. The proposed new sewing assembly line increases the system utilization and efficiency without any additional costs (Yemane et al., 2020). There are special models developed for the steel industry in terms of decreasing the time and waste amount for the cutting stock problem (Durakbasa and Gencyilmaz, 2022a). Moreover, the assignment models can be used to allocate the capacities of the vehicles concerning the low cost of the weekly logistics plan (Durakbasa and Gencyilmaz, 2022b).

Additionally, there are some examples from the food sector, too. Research conducted on food manufacturing used integer linear programming and heuristic algorithm to formulate a strategy to minimize the sum of all costs of manufacturing and warehouse operations. The constraints ensure that the quantity of items transferred from the manufacturing area to the warehouse equals the quantity manufactured, and a product can be manufactured only when the manufactured line is set up (Zhang et al., 2021). Ünal and Yüksel generated a nonlinear MIP model to minimize the total usage of fabric with constraints such as the number of plies belonging to each spreading must be less than the maximum number, the number of cut pieces must be greater than the order, and less than the excess cutting share for each size (Ünal and Yüksel, 2020). Among several studies in the literature, a MIP model is proposed in order to solve the machine–job assignment model for a textile company. There are two scenarios represented in this paper in terms of changing the working hours to minimize the total unused capacity of the machines. The assignment results with different working hours vary in order to meet the company's customer demand.

3. Problem Definition

This section gives a summary of the company, products, and production, and details of the problem. The in-house departments are design, development, sewing, cutting, printing, ironing, and packaging. The production department has 14 machines to deliver customer orders on time. The company makes production according to forecasted values for the next season as it follows seasonal production. They produce summer clothes in winter and winter clothes in summer. The monthly output of the company is 2,600 pants but this number increases to 7,000 pants by increasing staff and machine numbers. The previous year company had a demand for 35,000 pairs of pants and it takes 12 minutes to produce each pair of pants. The company has seven main types of machines, there are 3 overlock machines, 5 singer machines, and 2 piping machines with the same properties.

There are 1 belt, 1 iron, 1 cutting, and 1 packaging machine. In total, the company has 14 machines to satisfy the demand.

When the company finishes the forecasting, the development department visualizes the ideas of the customer with fashion designers to create and cut collection patterns in a stage called the drawing stage. Then the types and number of machines to produce the final products are estimated and the time needed to finish the production is calculated depending on the working hours of the employees besides the time needed for the machines to finish the job. The job is passed from development to the cutting and sewing department, then to printing and finishing, and lastly to the labels, ironing, and packaging department. In Figure 1, this process has been summarized.

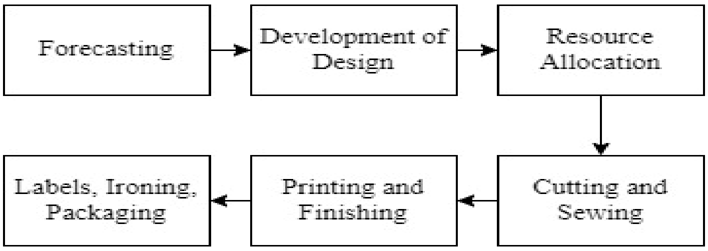

Figure 1. Process Flowchart of Production

The company focuses on the production of pants and three different types of pants are produced. The demand for pants is 15,000 pairs; however, it could not be met due to a lack of manpower and idle time. In this study, an alternative production planning method will be studied to minimize the total unused capacity of the machines and total costs; hence productivity will be maximized. The company's processes will be analyzed, and an optimal schedule will be offered that increases the system's productivity, reduces idle time, and meets the demand.

4. Methodology

This section includes an assignment model which was generated using a MIP method to appoint the phases of production of pants to the machines and to minimize the unused capacity, and the indices, parameters, and decision variables of this model.

In this study, these assumptions have been made:

- It is presumed that the demands, machine capacity, and working hours are in seconds.
- It is deemed that the required machine numbers, which are not found as integers, are rounded up to be an upper integer.

4.1. Model Indices, Parameters and Decision Variables

Hence, the following indices are used to develop the proposed model: i represents the number of all machines (overlock 1, overlock 2, overlock 3, singer 1, singer 2, singer 3, singer 4, singer 5, belt 1, iron 1, pipping 1, pipping 2, packaging 1, cutting 1) and j imposes represents all jobs that are done in machines (main part 1, main part 2, main part 3, main part 4, plato 1, plato 2, pocket 1, pocket 2, inner pockets 1, inner pockets 2, inner pockets 3, inner pockets 4, zipper 1, zipper 2, bridge 1, bridge 2, belt.). In addition, k is used for the types of machines (overlock, singer, belt, ironing, pipping, packaging, cutting). In order to solve this problem, the following sets are assumed to be known:
I: Set of all machines i
J: Set of all jobs j
K: Set of machine types k

Parameters that are required to define the assignment model are as follows:

$\mathbf{dem}_{jk}$ = Quantity of orders for job j to be delivered for the overlock type of machine (seconds)
$\mathbf{mcap}_{ik}$ = Capacity of overlock machine in seconds
$\mathbf{nmach}_{k}$ = Machine number in the facility

The decision variables that are used in the developed mathematical model are as follows:

$$y_i = \begin{cases} \mathbf{1, if\ the\ machine}\ \boldsymbol{i}\ \mathbf{is\ used} \\ \mathbf{0,\ \ otherwise} \end{cases}$$

$$x_{ij} = \begin{cases} \mathbf{1, if\ machine\ i\ does\ job}\ \boldsymbol{j} \\ \mathbf{0,\ \ otherwise} \end{cases}$$

$$\mathbf{unusedcap_{ik}\ =\ unused\ capacity\ of\ the\ machine}\ \boldsymbol{i}\ \mathbf{of\ machine\ type}\ \boldsymbol{k}$$

4.2. Mathematical Model

The provided mathematical model is as follows:

$$\min z = \sum_i \sum_k \text{unusedcap}_{ik} \tag{1}$$

s.t.

$$\sum_i x_{ij} = 1 \quad \forall j \tag{2}$$

$$\sum_j (x_{ij} * dem_{ik}) + \text{unusedcap}_{i,k} = \sum_j mcap_{j,k} * y_i \quad \forall i \in I, \forall k \in K \tag{3}$$

$$\sum_j x_{ij} \le nmach_k * y_i \quad \forall i \in I, \forall k \in K \tag{4}$$

$$y_i \in \{0,1\} \quad \forall i \in I \tag{5}$$

$$x_{ij} \in \{0,1\} \quad \forall i \in I, \forall j \in J \tag{6}$$

$$\text{unusedcap}_{ik} \ge 0 \quad \forall i \in I, \forall j \in J \tag{7}$$

The objective function is given in Equation (1) which minimizes the total unused capacity. Equation (2) indicates that each job must be assigned to a machine. Equation (3) illustrates the number of machines that are allocated to their unused capacity, must be balanced with the capacities of each machine. To associate the binary variables, Equation (4) is used to denote that the sum of assigned jobs must be less than and equal to the number of required machines. The integrality of the decision variables is represented by Equation (5) and Equation (6). Finally, the non-negativity of the decision variables is represented with Equation (7).

5. Implementation and Results

In this section the results of the MIP model and GAMS software are analyzed and compared with different scenarios, to achieve an optimal solution to minimize unused capacity and idle time. Hence, the proposed model is formulated in GAMS 35 (Brooke et al., 1998) and solved using the CPLEX 20 solver to find the optimal solution. The model is run on a computer of 2.9 GHz and 16 GB of RAM which takes a very short time. The characteristics of the proposed model are given in the following Table 1.

Table 1. Model Characteristics

Blocks of Equations	22
Single Equations	95
Blocks of Variables	4
Single Variables	207
Non Zero Elements	591
Discrete Variables	192
Generation Time (Seconds)	0.609
Solver Memory (MB)	4

5.1. Data Collected

The needed data was obtained from the company to solve the assignment problem by developing a MIP model via GAMS software. The purpose of this model is to try to minimize unused machine capacity for the selected product. The product is pants that consist of 5 phases of production. The product's demand is 15,000 pairs and it should be delivered within 30 days.

Each of the 5 phases which are essential for the completion of the product is set as a job to be assigned to a machine. Therefore, the demand for each job has been set as 15,000 pairs of pants in the developed model. This is because one job is apportioned to multiple machines, so the idle time on this machine is important for its primary purpose. The result of the amount of idle capacity over time is obtained at the end and unused time is minimized for each scenario. Therefore, the required quantity specified in 15,000 units per order is converted to time.

5.2. Output Data

GAMS software is used to solve the mathematical model provided in section 4. GAMS output shows the number of unused capacities for each type of machine. 7 types of machines are shown in Table 2 where the total amount of machines used by all jobs for each machine type. Every job is assigned to a machine running in a ratio that does not exceed the total number of machines required.

Table 2. The Total Number of Machine Used

Machine	Number of Assigned Machines
Overlock	2
Singer	2
Belt	1
Pipping	1
Ironing	1
Cutting	1
Packaging	1

Figure 2 shows a comparison of the used and unused capacities of the machines. The blue part shows the used capacity and the orange shows the unused capacity. The machine capacity is determined by the difference between the total working time in seconds per month and the total processing time of each job that is assigned to the machine in seconds per month. As can be seen, overlock and singer machines have less idle capacity compared to other machines.

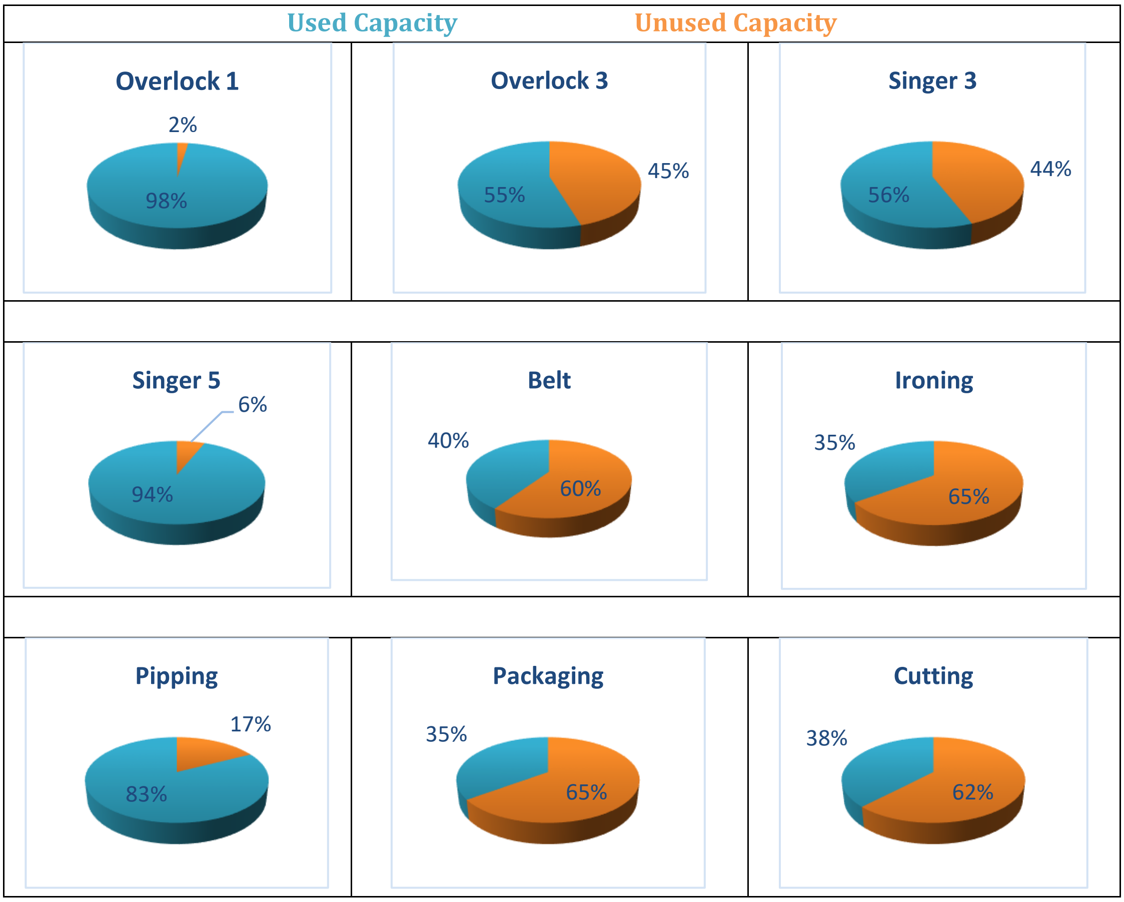

Figure 2. Comparison of the Used/Unused Capacities of Machines

5.3. Scenario I

The main objective of the first scenario is to monitor variations in unused capacity and the number of machines being used. The aim of changing the working hours is to represent if the company can meet the customer demand with flexible working hours. If the number of machines required, exceeds the maximum number of machines, a new machine will be used. Completion time, hourly demand, unit demand, and daily working hours remain as same as in section 5.1. In this scenario, a new product, velvet pants, is added to evaluate the unused capacity of the machines. In addition to the standard annual production of 15,000 fabric pants, 4,000 velvet pants were produced.

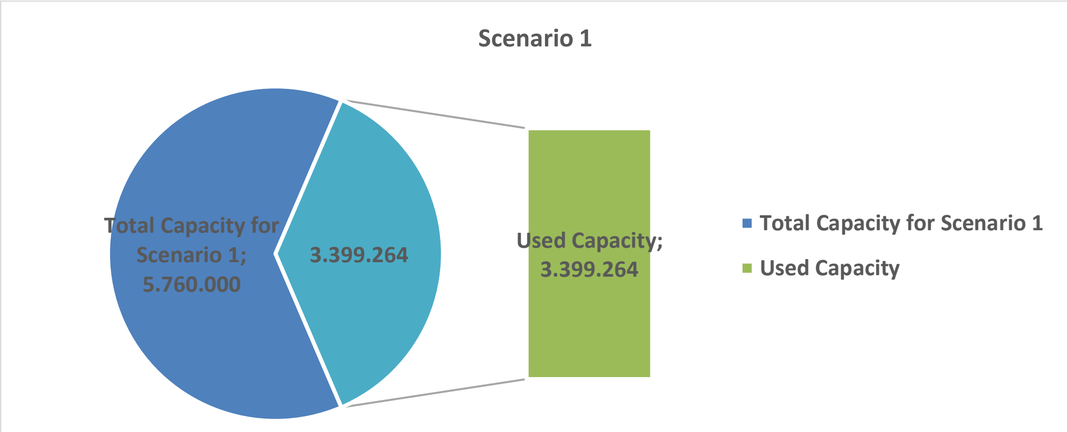

Figure 3. Total Used Capacity for Scenario 1

Each machine has 576,000 seconds of working hour capacity per month per second. Hence, there are 8 working hours in a day and 20 days in a month to calculate the total available capacity, 576,000 seconds are obtained per machine per month. Figure 3 indicates the time of available machine capacity usage. In Scenario 1, the company has 14 machines and each of them can work 576,000 seconds in a month. Each machine's working time is multiplied by the number of machines. In total there are 14 machines, however, 10 machines are assigned for Scenario 1. Thus, with 10 machines, the total available processing time capacity is 5,760,000 seconds. In scenario 1, 10 machines are used for a total of 3,399,264 seconds as represented in Figure 3. Therefore, in this scenario, the company uses time more efficiently when they produce the additional 4,000 units of velvet pants in comparison to the initial case with 9 machines.

As a result of this scenario, the production of velvet pants with an annual demand forecast of 4,000 has been realized. As a result, the number of machines used increased from 9 to 10. The machine's operating time in seconds and the company's working hours were kept at a constant value of 576,000 seconds.

5.4. Scenario II

The main purpose of the second scenario is to monitor the changes in the unused capacity when there is a reduction in working days and working hours. In this case, the time that machines are being used and the working times of the company were limited. The usual working hours are eight hours a day, five days a week, and four weeks a month. The company decided to produce fabric pants with an annual demand of 15,000, which continues to be produced in the usual way, by minimizing the working time of the machines. In the second scenario, the machines are arranged to work seven hours a day, three days a week, and four weeks a month. As an outcome of the obtained assignment model, it is determined that each machine should perform 302,400 seconds per month. After the assignment model, there are 12 machines assigned for Scenario 2 with a total available capacity of 3,628,800 seconds among 14 machines in the company. In Scenario 2, the company uses 2,682,500 seconds of total machine capacity determined for Scenario 2 as represented in the following Figure 4.

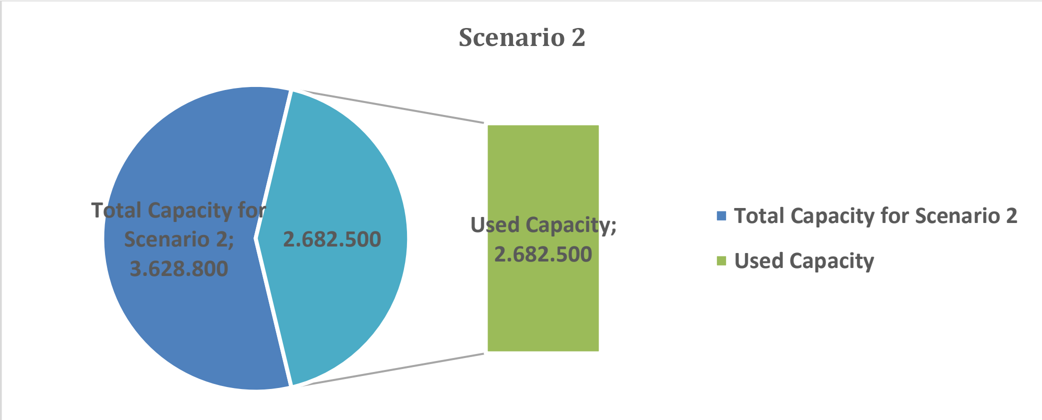

Figure 4. Total Used Capacity for Scenario 2

The data provided is used to solve the model presented in section 4, using GAMS software. In this scenario, to minimize the production time, the machines are used to their maximum capacity. Figure 5 shows a comparison of the number of machines that are used in the initial model and the first scenario. These results are obtained through GAMS software output. It is represented that when the working hours and days are reduced, the company needs to increase the number of machines as given in the figure. For Scenario 2, as long as the total working hours are decreased the company should use 3 overlock and 3 singer machines to satisfy the demand.

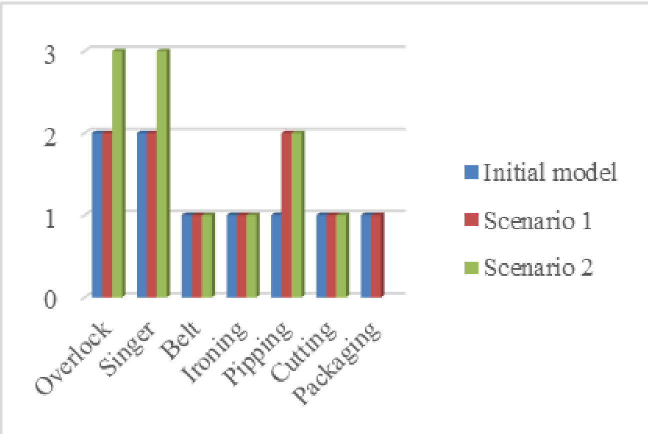

Figure 5. Comparison of the Number of Machines Used in Each Scenario

Table 3 interprets the comparison of conditions of the two scenarios below. As long as the parameters are changed the variables are affected. With the scenarios, the various conditions in terms of changing working hours are considered. Then the proposed model assigns each job to the corresponding machine, and the total assigned machine numbers are obtained in order to satisfy customer demand.

Table 3. Comparison of Two Scenarios

	Scenario I	**Scenario II**
Working Hour in a Day	8 hours	7 hours
Working Day in a Week	5 days	3 days
Working Week in a Month	4 weeks	4 weeks
Total Hours in a Month	160 hours	84 hours
Total Number of Machines Used	10 machines	12 machines
Available Working Hour per Machine	576,000 seconds	302,400 seconds
Used Capacity	3,399,264 seconds	2,682,500 seconds

6. Conclusion

The lack of expertise in production planning results in a disturbance for the whole company cycle. The improper production planning leads to the failure in meeting demand because of the lack of needed manpower and the high idle time. The inability to meet the demand would lead to a low level of customer satisfaction and increase the pressure on the employees due to overtime work. Subsequently, this could result in the company's loss if not realized as quickly as possible. In this paper, the company's processes were examined and realized to determine the optimal schedule that increases the system's productivity, reduces idle time, and meets the demand. To achieve that, data was gathered, MIP was applied to the assignment problem and GAMS software was used as a problem solver.

The process of making pants passes through 5 essential stages and the demand is 15,000 pants to be completed in 30 days. The model worked on minimizing the unused machine capacity by converting the specified demand into time. In this study, two scenarios were suggested where both could positively impact the company's performance. In the first scenario, jobs were examined, and the number of machines used was calculated. This scenario leads to a decrease in the unused machine capacities and minimized the lead time. In the second scenario, decreasing working hours to 7 hours and working days to 3 days were the main targets. So, the total monthly working hour is 302,400 seconds, and 12 out of 14 machines are used. The capacity of the 14 machines was calculated as 4,233,600. In the suggested scenario, the wasted time was decreased so the company became using 12 machines and used 73.92% of the machine time instead of 51.75% in their normal conditions. This scenario would increase work efficiency by minimizing the working time of producing the product which will lead to the ability to meet the demand in the needed time and even being able to increase it.

As a result, the company could implement one of the scenarios to be able to meet demand. Additionally, after the usage of a new scenario, there should be continuous monitoring to evaluate the performance of the cycle and to ensure continuous growth and success by meeting demands and customer satisfaction. It is recommended to do further studies that focus on the other weak points of the company that might have an impact on its performance. Moreover, the company is planning to expand by opening a new branch and increasing its production capacity. It is essential to pick the right location for the new branch, decide on the number of machines and workforce needed, and determine if the new branch would include a warehouse for the finished products or not, so future studies could include a studied decision about the new branch of the company.

Conflict of Interest

No conflict of interest was declared by the authors.

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