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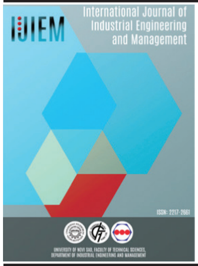

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A Developed Optimization Model for Mass Production Scheduling Considering the Role of Waste Materials

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ABSTRACT

Planning, scheduling and delivery of shipments in workshops and factories active in the field of custom manufacturing industries are two important arms in the decision-making process that are used to optimize or reduce the adverse effects of problems in production, so this is one of the important pillars within any company or manufacturing plant. The importance of this issue will become clear when this tool is used in the real world and the production platform to benefit the companies. In this research, we will investigate a medium-term period and a short-term schedule for the production of carton sheets in the printing and packaging industry, and provide a method for separating cutting and scheduling models, as well as an innovative method for the scheduling. The result of the research is the comparison of the proposed method with the common method used in the factory to measure the efficiency.

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1. Introduction

Production scheduling is an integral component of problems in different types of manufacturing companies. In general, the production schedule means that n works must be allocated to m machines such that makespan costs of all production processes are minimized [1, 2]. Therefore, finding a suitable solution in a reasonable time is an important factor for manufacturing units. The production process of many industries requires achieving smaller segments by cutting larger objects or, equivalently, putting smaller parts in a larger element. In this operation, parts of a larger object are turned into segments that are not usable and are dealt with as waste materials [3]. However, the decrease of this waste plays a signif-

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icant role in the reduction of costs and, therefore, has attracted the attention of several researchers in the past half-century as one of the topics of operations research known as the cutting problem [4-7]. Generally, cutting problems or similar issues can be observed in several industries, including auto body parts manufacturing, home appliances, building structures, shipbuilding, and aircraft, paper, clothing, leather, stone cutting, or in activities such as transportation, warehousing, packaging, and printing. On the other hand, a large trim loss will occur if the cutting process is carried out without the use of scientific methods, especially when the number and type of required pieces are high and variable [8-12]. This is mainly due to the extremely high number of patterns that can be developed, which makes the selection process difficult and experience-dependent. Accordingly, we need to present an algorithm that is able to propose an efficient technique for each combination of parts in a way that cutting based on the foregoing algorithm would guarantee the supply of required pieces while minimizing the waste percentage as much as possible.

Typically, we frequently use the term “scheduling” in our daily lives. However, the precise definition of the term and its role in achieving the goals of any activity are not completely tangible. In fact, any activity that starts with “when” and provides us with a sequence of tasks is defined as scheduling. In other words, scheduling means allocating limited resources to activities that require those resources [13]. Scheduling models play important roles in many decision-making ways. Transportation and distribution, information process, and planning and scheduling functions in a company depend on mathematical techniques and experimental methods to allocate limited resources to the activities that must be done. However, resource allocation must be carried out to achieve and optimize the company’s objectives.

On the other hand, reducing trim loss is unavoidable in industries such as metal sheets, carton sheets, paper rolls, and textiles, which practically deal with issues such as cutting patterns. Accordingly, proposing a solution for a decrease in makespan and production wastes has become necessary in the past decade due to the increase in production costs, especially in developing countries such as Iran. In any company, this issue is necessary in Enterprise Resource Planning (ERP), which links different decision-making points in the production system.

An ERP is used in the mentioned system known as the solutions program, which includes all the plant's systematic processes, including inventory control and warehousing, accounting, management, and monitoring of manufacturing programs and product delivery. However, the missing link in this relationship is between different manufacturing units and production schedules. Therefore, production planning and scheduling are mostly based on the scheduling unit for each unit in the plant separately. Nonetheless, a suitable scheduling result may not be achieved due to the high order number and combination of orders and their path. Accordingly, separate scheduling of each section might prevent the minimization of task makespan. Therefore, it is crucial to find a solution that guarantees the best manufacturing time and the plant's lowest trim loss. The cutting problem was first proposed by Kantorovich [14], who suggested a model for a single-dimension cutting problem with a demand that had to be solved through the identification of all cutting styles of a rod into required pieces. Meanwhile, this is only possible for extremely small-scale problems. Therefore, Gilmore and Gomory [15] presented a method entitled the column generation procedure, which is able to solve problems larger than that of Kantorovich. In this method, a mathematical model known as the general cutting model is formed by several primary cutting styles. Afterwards, a backpack model is formed to find a new and appropriate cutting style using shadow prices obtained from solving the mathematical model. After solving the backpack model, the resultant cutting style is added to or replaces the cutting model.

2. Literature Review

Sheet line machine produces carton sheets, which are produced from different types of paper sheets. The mentioned company is able to produce three and five-layer cartons and 10 different models of flute or corrugated sheets. The three-layer sheets with C, B, T, F flutes, which include three parts of external, internal and middle layers, and five-layer sheets with CB, CT, CE, BT, BE and TE flutes, which include two flute layers and a layer between the flutes in addition to the external and internal layers and shown in Figure 1.

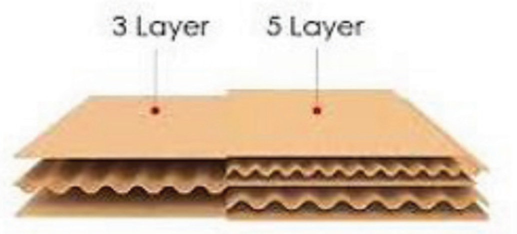

Figure 1. A schematic representation of three and five-layer cartons

Conventional sheet line machines encompass several sections, each playing a specific role in the carton sheet production process:

1. Singer facers: a sheet line machine comprises two single facer sections, each being responsible for the formation of flutes and a middle or an internal layer of a carton. In addition, every single facer encompasses several parts, the most important of which is corrugated rolls that lead to the formation of corrugated carton sheets, which can be replaced. Different types of corrugated rolls or flute rolls are required to produce each sheet flute.

2. Double facer: the sheets produced by single faces (an external layer and a flute or corrugated sheet) are stocked in the upper part of the device to enter the next part- i.e., double facer. Here, the external layer will be attached to the sheets depending on the three or five-layer production of the carton sheet.

3. Blanket: after this stage, since the layers are wet due to the use of glue, the manufactured sheets are heated by a set of heaters known as a blanket to create an integrated carton sheet.

4. Line to creases or cut-off blades: they are longitudinal and transverse cuts of carton sheets, and the line sheet machine existing in the plant is able to produce a maximum of six carton sheets next to each other. The machine has the ability to produce two simultaneous orders from the grid with each other. Combining two orders with each other creates complications for scheduling in the sheet line. In this respect, methods used in the modeling have been assessed. The feature of the cutting blades allows the machine to minimize trim loss with proper programming and is shown in Figure 2.

Dyckhoff [16] focused on the typology of cutting and packing problems by dividing cutting problems into four types: single, two, three- and four-dimensional cutting problems. The single-dimensional type is the most commonly used method, which is only able to cross-cut larger pages into smaller pages. Haessler et al. [17] proposed an integer model to solve a single-dimensional cutting problem. However, one of the weaknesses of this method is employing only a certain width, which means that parts with other widths cannot be solved. Accordingly, attempts were made to eliminate the model's weakness by using a binary variable. Since then, various industries have expanded and used the model depending on their needs. Since the formation of various cutting patterns leads to many model solution modes and based on research by Gradisar [18], the single-dimensional cutting problem and formation of its patterns in paper roll industries have been recognized as NP-hard problems, where achieving an exact solution in a short duration is not possible. Therefore, heuristic approaches must be used to solve the model in a reasonable time. In this regard, an example would be the use of the greedy randomized adaptive search procedure by Varela [19] or the genetics algorithm by Wang et al. [20].

Carton sheet manufacturing lines include several parts. According to a study by Pindo [21], it could be regarded as a flow shop that consists of four machines linearly behind each other. In 1976, Garey et al. [22] proved that a three or higher-machine flow shop problem is of NP-hard type. Therefore, heuristic or metaheuristic algorithms must be used to achieve an optimal solution. To date, several metaheuristic algorithms, such as simulated annealing (SA) and tabu search, have been used in this regard. The present study aims to propose an algorithm to achieve an optimal solution which is then compared with conventional algorithms used in the plant. In this respect, the results obtained from the heuristic algorithm are compared to the results of the traditional method to

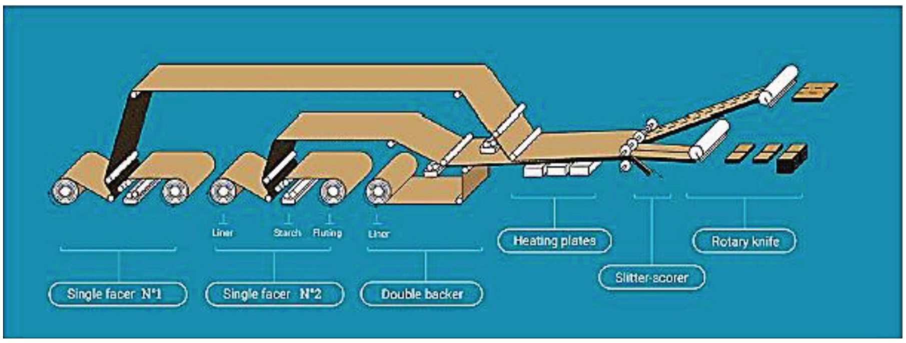

Figure 2. A schematic presentation of cardboard packaging sheet line

approve the efficiency of the desired method. Kawaguchi et al. [23] assessed the job-shop scheduling problem and presented a new improved algorithm to optimize it. The method considers optimal production scheduling and the optimal operation of energy plants simultaneously to minimize secondary energy costs. Lee et al. [24] suggested a modular construction project scheduling modeling using a genetic algorithm. The results show that implementing overall project processes and requirements is an efficient way to develop a modular construction project schedule.

Yue et al. [25] considered the uncertainty in the production optimization and proposed a robust optimization model by minimizing the maximum tardiness in the worst-case scenario overall jobs. Their model only needs the information on due date intervals. The worst-case scenario for a given sequence that belongs to a set containing only n scenarios is proved, where n is the number of jobs. Lin et al. [26] provided a research paper that was aimed at the theory and method of automobile mixed-model assembly line scheduling, analyzes its characteristics and difficulties, summarizes the related optimization objectives, and introduces the related algorithms, so as to make the scheduling problem of mixed model assembly line more clear. Perret et al. [27] argued that mass production is becoming increasingly instrumental for offering consumers individualized solutions and that fashion suppliers have to look for more sophisticated solutions. With the deduction of a mathematical model derived from production sequencing, it became evident that sustainability can be associated with a level production schedule and that cost-based production optimization helps achieve holistic sustainability in the fashion industry. These researchers additionally deliver a cost-based optimization approach that fashion companies operating in a mass customization production layout can quickly implement without extensive know-how.

After completing the literature review, it can be concluded that the main contribution of this paper is to provide a mathematical model and approximate solution method to optimize mass production scheduling by considering the role of waste materials.

3. Problem Statement

This study focuses on the optimization of the cutting problem and proper scheduling for the sheet line to simultaneously reduce the amount of trim loss and the makespan of the last work in each time of using the model of minimum sequence-dependent preparation times. There are several customers in this problem, and each customer's demand for each product is certain, and works are entered into the production program based on the delivery date. The whole research can be summarized as Figure 3.

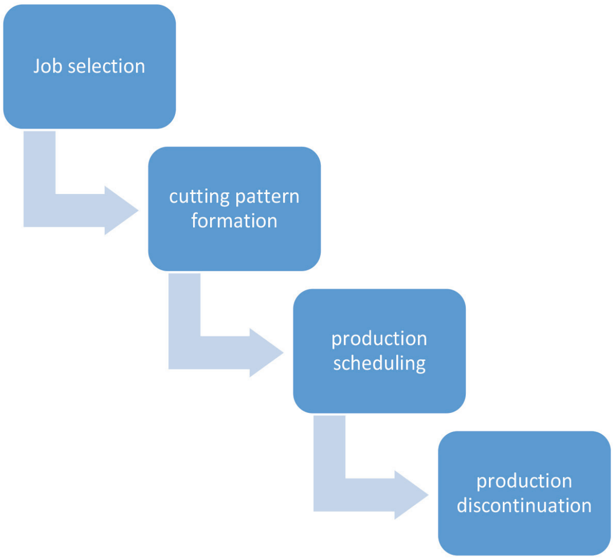

Figure 3. Order of activities in a period

All activities are divided into two Mo and Co categories in the first section. The first orders must be included in the sheet line plan for the next two days, and the second type of orders have a longer delivery time. First, all Mo activities are selected in the job selection model. The jobs will enter the next stage if they have a forecast time of 36 hours (three 12-hour production shifts). Otherwise, orders are taken care of one by one in case of the presence of Co orders so that the predicted time of the three shifts is completed. In the second section, the selected activities must be turned into specific patterns with minimum trim loss. This should be followed by performing a scheduling process on the set of jobs. Due to the several limitations in this work, the problem is divided into two parts of pattern creation and cutting problem, and on the other hand, the scheduling model.

4. Methodology

Pattern creation and cutting planning model will lead to the production of cutting patterns and solving the cutting model to create a set of tasks to be entered into the scheduling algorithm: in order to solve an ILP cutting model, cutting patterns should be generated first due to their role in the cutting model as input parameters. Cutting patterns will be justifiable when the number of sheets of each carton in each pattern and the minimum amount of trim loss do not exceed the roll width [30-34]. Therefore, this issue must be regarded in the written pseudocode. The minimum trim loss is used in carton sheet production because the sides of sheet rolls may not be completely usable due to transportation or any other reason. Therefore, the edges of the sheet rolls must be neglected to a certain extent. In addition, the maximum trim loss is used in the pseudocode since the machine can output two orders side by side simultaneously. Therefore, when an order of a cutting pattern exists, the waste parts could be used for another order with a smaller width [35]. The pseudocode is presented in Figure 4.

```
Pseudo code
For (cspo) do
    MaxOut_cspo = ⌊MaxWidth / OrderWidth_cspo⌋
    If (MaxOut_cspo >6) then
        MaxOut_cspo =6
    Endif
    CurOut_cspo =MaxOut_cspo
Endfor

For (cspo) do
    For (w|WidthAvailable_w,bg=1) do
        While (CurOut_cspo>0) do
            If (CurOut_cspo *sw_cspo+MinTrim) ≤ w then
                Add new pattern p to set cutting patterns
                gw_p = w
                nw_p = CurOut_cspo *sw_cspo
                tl_p = gw_p - nw_p
                pwp_p,w = 1
                pno_p,cspo = CurOut_cspo
            Endif
            CurOut_cspo = CurOut_cspo -1
        Endwhile
        CurOut_cspo = MaxOut_cspo

        For (cspo2|cspo2 > cspo) do
            While (CurOut_cspo2>0) do
                If (CurOut_cspo *sw_cspo+ CurOut_cspo2 *sw_cspo2+MinTrim ≤ w) and
                (CurOut_cspo *sw_cspo+ CurOut_cspo2 *sw_cspo2+MaxTrim ≥ w) then

                    Add new pattern p to set cutting patterns
                    gw_p = w
                    nw_p = CurOut_cspo *sw_cspo + CurOut_cspo2 *sw_cspo2
                    tl_p = gw_p - nw_p
                    pwp_p,w = 1
                    pno_p,cspo = CurOut_cspo
                    pno_p,cspo2 = CurOut_cspo2
                Endif

                CurOut_cspo2 = CurOut_cspo2 - 1

                If (CurOut_cspo2=0) then
                    CurOut_cspo2=MaxOut_cspo2
                    CurOut_cspo=CurOut_cspo-1
                Endif
            Endwhile
            CurOut_cspo =MaxOut_cspo
            CurOut_cspo2=MaxOut_cspo2
        Endfor
    Endwhile
Endfor
```

Figure 4. The pseudocode of the proposed algorithm

The pseudocode includes three steps:

Step 1: involves application limitations of the machine and expresses that the machine is able to only produce six cuts of each order, and this limitation is related to the cutting blade. The maximum number of cuts next to each other will be equal to six if the total number is higher than six.

Step 2: for each category of similar orders and width of the existing rolls based on trim loss, a cutting pattern is created that includes only one order.

Step 3: since the machine is able to simultaneously produce two orders of one type of sheet and flute combination, the combined patterns of the orders must be created in a category. Therefore, the pseudocode focuses on the generation of these patterns in step 3.

Each combination will be entered into the cutting modeling in the section of created patterns so that the least amount of waste is produced from the order patterns and production area of each type of design. Table 1 presents each element of the mathematical model.

The objective function guarantees minimum trim loss in the activated set of cutting patterns. The sheet line has some constraints: the length of implementation of a cutting pattern, which must be at least equal to 50 m. Constraints 2 express the need for an App to exhibit an auxiliary binary variable, which demonstrates the activation of pattern p {0 if unactivated; 1, if activated}. This variable is required since all cutting patterns are not activated. when using such auxiliary variables, constraints must be considered in a way that the length of execution be zero in case of lack of activation of the cutting pattern. This is carried out by Constraints 3, which uses BigM parameter, in which the maximum length of implementation of a pattern must be smaller or equal to the BigM parameter. Another constraint is related to the implementation of sheet length with a certain width (mrlw).

This length of use of each roll with a certain width must be greater than or equal to 200 m. Operators will not have adequate time to change the paper rolls if the length of use of a paper width is less than 200 m, which leads to the discontinuation of the sheet production line. The APWw auxiliary binary variable is used in this constraint, which is expressed in constraint four and determines whether the w sheet width is active or not {0 in case of lack of activation; 1 in case of activation}. In addition, the same process used for App is implemented for the APW auxiliary binary variable. In addition, a BigM parameter is used in this regard. Moreover, the pwppw parameter is a binary variable that will be zero if the pattern is not of width w and one if the pattern is of width w. This is expressed in constraints 5. Finally, constraints 6 present the relationship between the number of produced orders with activated pattern length, including order. In order to clarify the structure of the cutting algorithm, Figure 5 is provided.

Table 1. Indexes, variables and parameters in the model

Indexes	
ci	Same-grade jobs placed in a cutting pattern.
o	Orders or jobs
p	Cutting pattern numbers from 1 to i
w	Width of rolls
o	Order number from 1 to n
Parameters and Variables	
RLPp	Length of the pattern activated from p plan
mrlci	Minimum activated length of each order pattern
mrlw	Minimum activated length of each width roll
BigM	Maximum activated length or maximum total length of activated patterns
slo	Sheet length of order O
pnop,o	The number of sheets placed next to each other of order O in p cutting pattern - expresses the number of cuts.
onocspo	The number of output products of order o of each sheet – expresses the number in the mold.
pQo	The number of output products of order O
rqo	The number of the demanded product of O type
APp	1, in case of activation of p pattern – otherwise, 0.
APWw	1, in case of activation of roll with width w – otherwise, 0.
pwppw	1, in case of the p pattern is of a roll with width w – otherwise, 0.

$$min.\, z = RLP_p \times tl_p \quad (1)$$

St:

$$RLP_p \geq mrlci \times AP_p \quad \forall p \quad (2)$$

$$RLP_p \leq BigM \times AP_p \quad \forall p \quad (3)$$

$$\sum_p RLP_p \times pwp_{p.w} \geq mrlw \times AP_w \quad \forall w \quad (4)$$

$$\sum_p RLP_p \times pwp_{p.w} \leq BigM \times AP_w \quad \forall w \quad (5)$$

$$PQ_o = \sum_p \frac{RLP_p \times pno_{p,o} \times ono_o}{sl_o} \quad \forall o \quad (6)$$

$$RLP_p \geq 0 \quad (7)$$

$$PQ_o \geq 0 \;\&\; integer \quad (8)$$

$$APp \;\&\; APWw \;\&\; pwp_{p,w} = Binary\{0,1\} \quad (9)$$

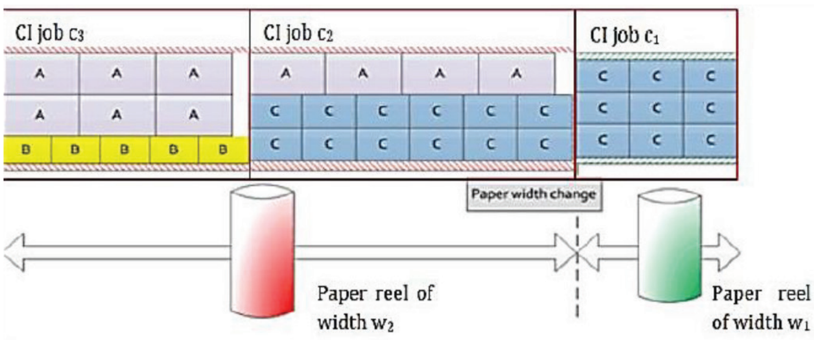

Figure 5. Result of the cutting algorithm obtained from the set of solutions, which includes one or several cutting patterns for entrance into the scheduling algorithm

4.1. Cutting Model and Pattern Formation

In sheet line scheduling, the set of solutions obtained in the previous stage is assumed to be impartible. Therefore, all jobs must be finished when a set is started. Accordingly, the algorithm developed based on the heuristic method is (scheduling assumptions):

1. Machines are always available.
2. The production time forecast file is a computational file that provides us with an initial production time without considering downtime to calculate the planning horizon based on the production conditions and three or five-layer products and their area (the mentioned file is part of the company's confidential information).
3. Orders are impartible and inseparable.
4. Cutting sets are impartible.

The schematic view of the algorithm is presented in Figure 6.

4.2. Algorithm for Sheet Line Scheduling

Due to a lack of different flutes, it is practically impossible to present scheduling that yields accurate outcomes in a suitable time in a sheet line scheduling. Therefore, the best solution is to use heuristic and metaheuristic algorithms in these situations. There are multiple instructions for the generation of heuristic solutions, depending on the conditions of each company. In this regard, one of the best of these instructions, in case of having orders from all types of flutes, is as follows:

CB-C-CT-T-BT-B-BE-E-TE-CE+30MIN

As observed, the sheet line machine is able to produce six different flutes of five-layer and carton sheets and four different flutes of three-layer carton sheets. However, each flute replacement process takes 30 minutes. Therefore, 30 minutes will be added to the total scheduling when changing the flute from TE to CE due to the need to change flute number two of the machine to replace flute T with flute C. That, however, is not always the case. There might not be orders of all flute types in the daily schedule in the real world for any reason. In this situation, frequent flute change might be required, which leads to scheduling inefficiency. In this stage, the heuristic algorithm is proposed, as shown in Figure 7.

In this algorithm, the flutes are presented in pairs, with the exception of the first and second category flutes. In the case of the order of each flute category, both flutes will be added to the scheduling plan. In the end, the shortage of ordered flutes leads to their removal from the order. This, in fact, is an innovation of the complete count method, the result of which has the best adaptation to the conditions in the factory.

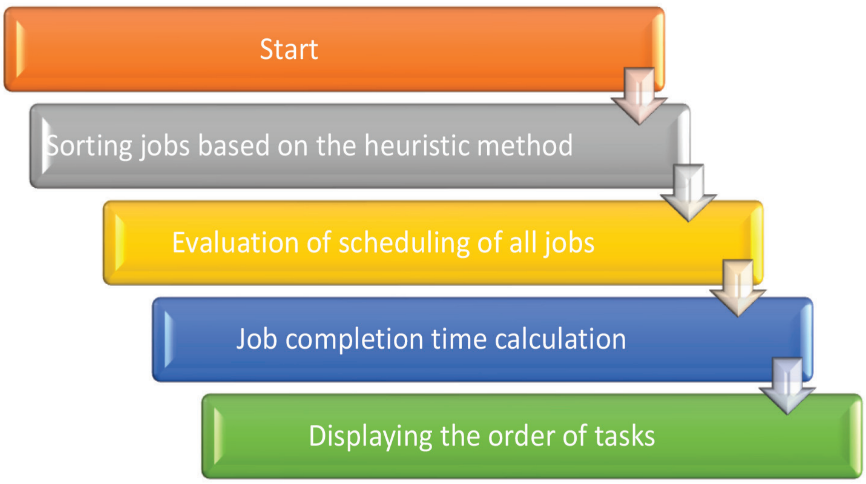

Figure 6. A schematic representation of the scheduling algorithm

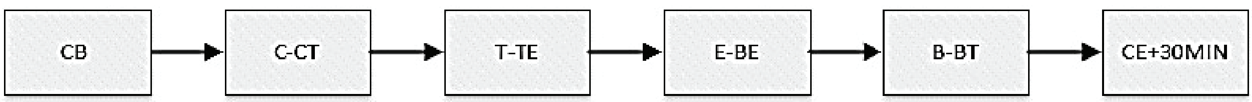

Figure 7. Scheduling heuristic algorithm

5. Computational Results

The proposed algorithm is programmed in PHP and the web. Given the lack of use of sample issues with cutting patterns in the studied plant, orders are selected for a 36-hour period to assess algorithm efficiency. In addition, the order pattern generation method and its output and the timing of a 12-hour shift are expressed to evaluate the efficiency of the solutions. The details of the examples are presented in Table 2 and Table 3.

To measure the efficiency of the order scheduling algorithm, a 12-hour shift is compared in two ways, one based on the company's common method of having all orders from all types of flutes and the other based on the innovative algorithm provided in Table 4.

After solving a representation of cutting patterns using the proposed algorithm instead of conventional methods, which rely more on chance and experience, trim loss decreases by 27% after solving different cutting patterns using the heuristic algorithm. Therefore, the use of the proposed algorithm can be considered a suitable solution to reduce trim loss, which is the result of the application of metaheuristic algorithms, including local search, genetics algorithm, and SA (due to the confidentiality of the information, disclosure of the algorithm used is against the rules of the factory understudy). In terms of scheduling, the company seeks to reduce the completion time of the last job in each production period. Therefore, a method is required to evaluate all sorting modes and machine activity allocation in a short period. Accordingly, the heuristic algorithm is used, and its results are compared to the conventional scheduling method. Based on the results, the proposed algorithm eliminates this issue and proposes the shortest production line scheduling period based on the conditions of the company.

Table 2. An example of orders with a similar combination for the creation of a cutting pattern

Order	Required Number	Order Width (mm)	Order Length (mm)	Roll Width Proposed in the Indent (mm)
A	2100	400	12100	3500
B	1800	520	1270	3600
C	980	425	1090	3050

Table 3. A comparison of the common method and the proposed algorithm

Plan Number	Roll Width (mm)	Number of Cuts			Plan Length (m)	trim loss (mm)	total trim loss (m)
		A	B	C			
1	2000	0	0	5	217	35	7.6
2	2400	4	2	0	98	46	4.5
3	2000	3	2	0	465	33	15.3
The plan made by the common method							
Plan Number	Roll Width (mm)	Number of Cuts			Plan Length (m)	trim loss (mm)	total trim loss (m)
		A	B	C			
1	2000	0	0	5	217	35	7.6
2	2400	5	1	0	358	62	22.2
3	2500	0	5	0	129	82	10.5

Table 4. A comparison between common and heuristic scheduling methods

Cutting patterns for a production shift											
Type of flute	CB	CT	CE	BT	BE	TE	C	B	T	E	Scheduling deviation rate (min)
Number of cutting patterns	3	0	0	2	2	0	3	2	0	2	
Innovative algorithm scheduling pattern	CB+C+E+EB+B+BT+BT+B+EB+EC+CB+CB+C										0
Common scheduling pattern	CB+C+30+BT+B+BE+E+E+BE+B+BT+30+C+BC+BC+B										60

6. Conclusion

In this paper, we evaluated a one-dimensional cutting problem with demand. Most researchers have addressed the cutting problem with the aim of reducing trim loss on the sheet separately, without considering the demand for parts and different widths. Meanwhile, most real cutting problems are in the form of a cutting problem with the demand and width of different orders. However, since this problem was of NP-complete type, a heuristic algorithm was required to solve it practically. Therefore, a heuristic algorithm directly solved a cutting problem with the demand and width of variable cuts, which were considered inputs of the scheduling problem. Moreover, since the scheduling problem is also an NP-hard problem, heuristic and metaheuristic methods must be used to achieve an optimal solution. Given the significant importance of search of all solution space for the company, the presentation of an innovative method based on searching the entire solution space and its analogy with the common scheduling method covered this weakness.

Due to the prevailing market conditions, it is recommended that demand for each product be considered probabilistically, and then the proposed model be expanded to reach an optimal solution.

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References

[1] H. Rjoub, T. Türsoy, and N. Günsel, “The effects of macroeconomic factors on stock returns: Istanbul Stock Market,” Studies in Economics and Finance, vol. 26, no. 1, pp. 36–45, 2009, doi: 10.1108/10867370910946315.

[2] T. Tursoy, N. Gunsel, and H. Rjoub, “Macroeconomic factors, the APT and the Istanbul stock market,” International Research Journal of Finance and Economics, vol. 22, pp. 49-57, Dec. 2008.

[3] H. Rjoub, I. Civcir, and N. G. Resatoglu, “Micro and macroeconomic determinants of stock prices: The case of Turkish banking sector,” Romanian Journal of Economic Forecasting, vol. 20, no. 1, pp. 150-166, 2017.

[4] H. Rjoub, “Stock prices and exchange rates dynamics: Evidence from emerging markets,” African Journal of Business Management, vol. 6, no. 13, pp. 4728-4733, 2012.

[5] A. Alfadli, and H. Rjoub, “The impacts of bank-specific, industry-specific and macroeconomic variables on commercial bank financial performance: evidence from the Gulf cooperation council countries,” Applied Economics Letters, vol. 27, no. 15, pp. 1284-1288, 2020, doi: 10.1080/13504851.2019.1676870.

[6] Alwreikat, Ahmad AM, and Husam Rjoub. "Impact of mobile advertising wearout on consumer irritation, perceived intrusiveness, engagement and loyalty: A partial least squares structural equation modelling analysis." South African Journal of Business Management, vol. 51, no. 1, pp. 1-11, 2020, doi: 10.4102/sajbm.v51i1.2046.

[7] A. D. Fofack, A. Aker, and H. Rjoub, “Assessing the post-quantitative easing surge in financial flows to developing and emerging market economies,” Journal of Applied Economics, vol. 23, no. 1, pp. 89-105, 2020, doi: 10.1080/15140326.2019.1710421.

[8] H. Rjoub, C. B. Iloka, and V. Venugopal, “Changes in the Marketing Orientation Within the Business Model of an International Retailer: IKEA in Malaysia for Over 20 Years,” in Handbook of Research on Current Trends in Asian Economics, Business, and Administration, B. Akkaya, K. Jermsittiparsert, and A. Gunsel, Eds. New York, NY, USA: IGI Global, 2022, pp. 170-190, doi: 10.4018/978-1-7998-8486-6.ch009.

[9] H. Rasay, and A. M. Golmohammadi, “Modeling and analyzing incremental quantity discounts in transportation costs for a joint economic lot sizing problem,” Iranian journal of management studies, vol. 13, no. 1, pp. 23-49, 2020, doi: 10.22059/IJMS.2019.253476.673494.

[10] A. M. Golmohammadi, A. Asadi, Z. A. Amiri, and M. Behzad, “Design of a facility layout problem in cellular manufacturing systems with stochastic demands,” Management Science Letters, vol. 8, no. 11, pp. 1133-1148, 2018, doi: 10.5267/j.msl.2018.8.010.

[11] A. M. Golmohammadi, M. Honarvar, H. Hosseini-Nasab, & R. Tavakkoli-Moghaddam, “A bi-objective Optimization Model for a Dynamic Cell Formation Integrated with Machine and Cell Layouts in a Fuzzy Environment,” Fuzzy Information and Engineering, vol. 12, no. 2, pp. 204-222, 2020, doi: 10.1080/16168658.2020.1747162.

[12] H. Rasay, and A. M. Golmohammadi, “Modeling and analyzing incremental quantity discounts in transportation costs for a joint economic lot sizing problem,” Iranian journal of management studies, vol. 13, no. 1, pp. 23-49, 2020, doi: 10.22059/ijms.2019.253476.673494.

[13] G. Geng, Y. Wang, L. Zhang, and M. Xiao, “Optimization of cutting parameters in double-excitation ultrasonic elliptical vibration cutting of 630 stainless steel,” The International Journal of Advanced Manufacturing Technology, vol. 114, no. 7-8, pp. 2169-2183, 2021.

[14] L.V. Kantorovich, “Mathematical Methods of Organizing and Planning Production,” Management Science, vol. 6, no. 4, pp. 366-422, 1960, doi: 10.1287/mnsc.6.4.366.

[15] P. C. Gilmore, and R.E. Gomory, “A Linear Programming Approach to the Cutting - Stock Problem,” Operation Research, vol. 9, no. 6, pp. 849-859, 1961, doi: 10.1287/opre.9.6.849.

[16] H. Dyckhoff, “A typology of cutting and packing problems,” European Journal of Operational Research, vol. 44, pp. 145-159, 1990.

[17] R. W. Haessler, and P. E. Sweeney, “Cutting stock problems and solution procedures,” European Journal of Operational Research, vol. 54, pp. 141-150, 1991.

[18] M. Gradisar, G. Resinovic, and M. Kljajic, “Evaluation of algorithms for one-dimensional cutting,” Comput Oper Res, vol. 29, no. 9, pp. 1207–1220, 2002.

[19] R. Varela, C. R. Vela, J. Puente, M. Sierra, and I. González-Rodríguez, “An effective solution for a real cutting stock problem in manufacturing plastic rolls,” Ann Oper Res, vol. 166, no. 1, pp. 125–146, 2009.

[20] W. C. Weng, C. T. Yang, and C. F. Hung, "The optimization of section steel arrangement for ship construction associated with cutting rule by genetic algorithm," in Proceeding of the 17th Asian-Pacific Technical Exchange and Advisory Meeting on Marine Structure, Tainan, Taiwan, 2003, pp. 237–246.
[21] M. Y. Cheng, Y. C. Fang, and C. Y. Wang, "Auto-tuning SOS Algorithm for Two-Dimensional Orthogonal Cutting Optimization," KSCE Journal of Civil Engineering, vol. 25, pp. 3605–3619, 2021, doi: 10.1007/s12205-021-0522-y.
[22] M. R. Garey, D. S. Johnson, and R. Sethi, "The complexity of flow shop and job shop scheduling," Math. Oper. Res, vol. 1, pp. 117–129, 1976.
[23] M. Thenarasu, K. Rameshkumar, S. P. Anbuudayasankar, G. Arjunbarath, and P. Ashok, "Development and selection of hybrid dispatching rule for dynamic job shop scheduling using multi-criteria decision making analysis (MCDMA)," Int. J. Qual. Res., vol. 14, no. 2, pp. 487–504, 2020, doi: 10.24874/IJQR14.02-10.
[24] T. Afonso, A. C. Alves, P. Carneiro, and A. Vieira, "Simulation pulled by the need to reduce wastes and human effort in an intralogistics project," Int. J. Ind. Eng. Manag., vol. 12, no. 4, pp. 274–285, 2021, doi: 10.24867/IJIEM-2021-4-294.
[25] F. D'Amico, D. A. Rossit, and M. Frutos, "Lot streaming Permutation Flow shop with energy awareness," Int. J. Ind. Eng. Manag., vol. 12, no. 1, pp. 25–36, 2021, doi: 10.24867/IJIEM-2020-1-274.
[26] E. G. Popkova, "Quality of Digital Product:Theory and Practice," Int. J. Qual. Res., vol. 14, no. 1, pp. 201–218, 2020, doi: 10.24874/IJQR14.01-13.
[27] I. Spasojević, S. Havzi, D. Stefanović, S. Ristić, and U. Marjanović, "Research Trends and Topics in IJIEM from 2010 to 2020: A Statistical History," Int. J. Ind. Eng. Manag., vol. 12, no. 4, pp. 228–242, 2021, doi: 10.24867/IJIEM-2021-4-290.
[28] A. Goli, H. Khademi-Zare, R. Tavakkoli-Moghaddam, A. Sadeghieh, M. Sasanian, and R. Malekalipour Kordestanizadeh, "An integrated approach based on artificial intelligence and novel meta-heuristic algorithms to predict demand for dairy products: a case study," Netw. Comput. Neural Syst., vol. 32, no. 1, pp. 1–35, 2021, doi: 10.1080/0954898X.2020.1849841.
[29] E. B. Tirkolaee, A. Goli, P. Ghasemi, and F. Goodarzian, "Designing a sustainable closed-loop supply chain network of face masks during the COVID-19 pandemic: Pareto-based algorithms," J. Clean. Prod., vol. 333, 2022, doi: 10.1016/j.jclepro.2021.130056.
[30] A. Goli and H. Mohammadi, "Developing a sustainable operational management system using hybrid Shapley value and Multimoora method: case study petrochemical supply chain," Environ. Dev. Sustain., 2021, doi: 10.1007/s10668-021-01844-9.
[31] R. Ojstersek, B. Acko, and B. Buchmeister, "Simulation study of a flexible manufacturing system regarding sustainability," Int. J. Simul. Model., vol. 19, no. 1, pp. 65–76, 2020, doi: 10.2507/IJSIMM19-1-502.
[32] Y. Xu, S. Thomassey, and X. Zeng, "Optimization of garment sizing and cutting order planning in the context of mass customization," The International Journal of Advanced Manufacturing Technology, vol. 106, no. 7, pp. 3485-3503, 2020.
[33] S. Zhu, F. Zhang, J. Bai, L. Zhao, and H. Zhao, "Optimization analysis of ultra-precision flying-tool cutting machine for optical elements," in Fourth International Conference on Photonics and Optical Engineering, 2021, vol. 11761, p. 117610T.
[34] M. Kuntoğlu, A. Aslan, D. Y. Pimenov, K. Giasin, T. Mikolajczyk, and S. Sharma, "Modeling of cutting parameters and tool geometry for multi-criteria optimization of surface roughness and vibration via response surface methodology in turning of AISI 5140 steel," Materials, vol. 13, no. 19, pp. 4242, 2020, doi: 10.3390/ma13194242.
[35] S. N. Fayzimatov, Y. Y. Xusanov, and D. A. Valixonov, "Optimization Conditions of Drilling Polymeric Composite Materials," The American Journal of Engineering and Technology, vol. 3, no. 2, pp. 22-30, 2021.