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Website Design Optimization of Cutting Stock Problem on 1 and 2 Dimentions by Using Genetic Algorithm

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ABSTRACT

Many industries produce waste that cannot be reused, especially in the process of cutting raw materials. The use of raw materials that are not optimal indicates that the pattern of item placement on raw materials produces waste which cannot be used for other needs. This problem is known as cutting stock problem. This study aims to reduce the waste that arises when cutting raw material sheets into small pieces needed in the industry by developing a website as a tool in completing the placement of cutting patterns on raw materials. The developed website describes the results of optimal placement patterns in the form of images for 1 and 2 dimensions with the genetic algorithm method as an optimization algorithm using rectangle packing sequence in codification, cornerset modification algorithm on decoding, parameterized uniform crossover on crossover, roulette wheel on selection, and random generated mutations. Website development is made with hypertext markup language to display various information needed, cascading style sheets to arrange components in structured and uniform websites, and javascript to create genetic algorithm logic. This research resulted in the placement of cutting patterns on sheets of raw material on the canvas by labeling the names of each item.

Keywords: *Cutting Stock Problem, Genetic Algorithm, Optimization, Website Design*

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ABSTRAK

Banyak industri yang menghasilkan waste yang tidak dapat digunakan kembali terutama dalam proses pemotongan bahan baku. Pemakaian bahan baku yang tidak optimal menandakan bahwa pola penempatan item pada bahan baku menghasilkan waste yang tidak dapat digunakan. Permasalahan ini dikenal dengan cutting stock problem. Penelitian ini bertujuan untuk mengurangi waste yang muncul saat pemotongan lembaran bahan baku menjadi potongan kecil yang dibutuhkan industri melalui pengembangan website sebagai alat bantu dalam penyelesaian penempatan pola pemotongan pada bahan baku. Website yang dikembangkan memberikan hasil pola penempatan yang optimal berupa gambar untuk 1 dan 2 dimensi pemotongan dengan metode algoritma genetika sebagai algoritma optimasi dengan menggunakan rectangle packing sequence pada kodifikasi, algoritma modifikasi cornerset pada dekodifikasi, parameterized uniform crossover pada crossover, roullete wheel pada seleksi, dan random generated pada mutasi. Pengembangan website dibuat dengan hypertext markup language untuk menampilkan berbagai informasi yang dibutuhkan, cascading style sheet untuk mengatur komponen dalam website terstruktur dan seragam, dan javascript untuk membuat logic algoritma genetika. Penelitian ini menghasilkan penempatan pola pemotongan pada lembaran bahan baku dalam canvas dengan pemberian label setiap item.

Kata kunci: *Optimasi, Cutting Stock Problem, Algoritma Genetika, Perancangan Website*

INTRODUCTION

The problem of this research is about utilization and processing of raw materials to fullfill consumer needs on industrial cutting process that has not been optimal. It is because the placement pattern cutting are in varied size, so that the raw material sheet produces a lot of waste. This makes company spend more cost on raw material purchases.

A production manager responsible to control local and import raw material purchase to meet the consumer needs but still has to manage it efficiently. To minimalize the purchasing of raw materials and maximize the use of materials, the demand of consumer arrange simultanously with raw materials stock in the company. Cutting stock problem often arises in the paper industry, steel industry, metal industry, textile industry, and so on. The high demand of raw material in paper industry, iron, and furniture influence the industry player to put intention into problem that often came up in the production process especially on raw material utilization.

Lin's research [9] outlines about cutting stock wooden board 1 dimention according to adaptive genetic algorithm. This paper illustrates about the wooden demand which is getting higher compare to the supply caused the extensive logging to forest resource. Calculation process of optimization result were achieved after twenty iteration. The initial length of the wood were 321 cm with remaining raw material as much as 4 cm. Utilization material of wood are 98%. Meanwhile, Bonnevay [2] did the research related to the use of genetic algorithm in paper cutting industry on 2 dimention and the problem were focusing on the placement of pattern, linear programming (determining the stock sheet) and combinatorial (the number of picture on each pattern). The result of this research are very significant with some heuristic additional which able to increase the calculation process, solution quality, and placement process. Shahin [13] did the research by eliminating iron waste from the cutting result correspond into the demand for cunstruction and improving linear programming in genetic algorithm. The final result of this research shown that construction waste reduce as much as 28,92% and succeed to eliminate through a better planning.

In this research, modification of implementation genetic algorithm on the cutting process industry which is able to be calculated whether optimum result that has been achieved are able to reduce the amount of waste on 1 and 2 dimension. This result not only discuss about calculation but also implementation of this research on the optimization application of cutting stock problem on website based. Website implementation used hypertext markup languange, cascading style sheet, and javasript. The method that suggested in solving the cutting stock problem has different layout for each cutting dimension.

LITERATURE REVIEW

Cutting Stock Problem

The understanding about cutting stock problem in general is the cutting of length object as raw material or container to accomodate some smaller object as demand to fullfill the user needs, minimize the total object which has been cut, minimize waste from clipped product, minimize cost from cutting the object, and so on [3].

Genetic Algorithm

The genetic algorithm is an algorithm which implemented the understanding about natural evolution in solving the problems. The approach was implemented in algorithm by using random option to create the best solution in condition which maximize the suitability and called by fitness [7].

Website Developing

Website is a bunch of web which is correlated each other and also some correlation of files. Website stand of page and homepage (Gregorius, 2000, h:30). The design of web is one of important element to attract the attention of visitor on the web design. The step on website developing according to Lewis [8] are definition, design, developement, testing and launch, and maintenance.

METHOD

Genetic Algorithm

Scope

The scope that discuss in this research can be seen on tha table 1.

Table 1. Scope of Developing the Algorithm

Problem Description	Setting the cutting pattern on the raw mataeroal sheet so that utilization of material can be maximize, computation time cultivated to be faser so that the solution are more applicable
Objective Function	The optimization of utilizationon raw material sheet
Decision Variable	The picture of cutting pattern on the raw material
Barrier	Cutting side parallel with raw material sheet side, there is no outside cutting from raw material, and there is no intersect cutting pattern

Codification process

Codification by using random number as the chromosome represetation which is feasible on each code. Each chromosome solution were shaped from n gene, where n is the number of pattern cutting which will be cut

$$Chromosome = (gene1, gene2, \ldots, genen\text{-}1, genen) \qquad n = 1, 2, \ldots, n$$

Placement strategy were done by sort gene on the chromosome that has been given, called by rectangle packing sequence, such as shown on the picture 1. The function is to keep the solution that has been produced are stay on the global optimum.

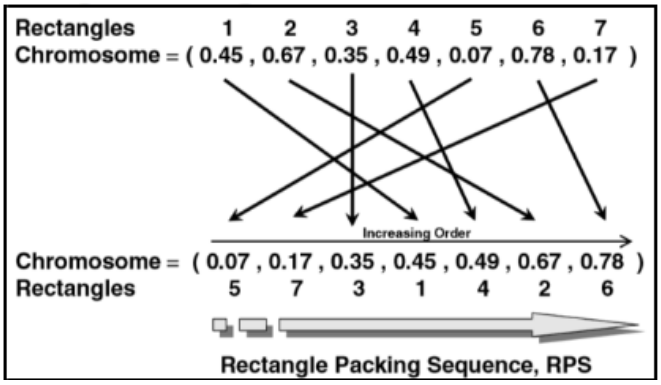


Figure 1. Decodification Chromosome Procedure

Decodification process

Decodification used placement pattern cutting concept by three information, those are, X axis, Y axis, and Ycorner. The step of placing are follows :

(1) Prepare the cornerset list {(0,0, ycorner)}
(2) Take the cutting pattern candidate which will be arranged
(3) Set i → 1
(4) Select item – i. Does the length of the pattern cutting less than the length of raw material sheet? If yes, continue to (4). If no, continue to (5)
(5) Does the wide of the pattern cutting less than the length of raw material sheet? If yes, continue to (4). If no, continue to (5)
(6) Does the item wide less than the remaining raw material sheet. If YES, continue to (8).

(7) Turn 90^o and does the length of item less than the wide of remaining raw material. If YES, continue to (8), If No, Continue to (9)
(8) Move item into Ycorner position and continue to (5)
(9) Revise cornerset which is available by the placement of new pattern cutting. Continue to (7)
(10) If the pattern still can not be placed, then set aside the pattern cutting and continur to (10)
(11) Raise item indeks i → i + 1. Repeat (3) – (9)
(12) Repeat (1) – (9), so that there is no free pattern cutting

Fitness Function

Fitness function are modified from percentage of trim loss equation (1) on the journal [5]

$$\%\text{Trim Loss} = \frac{\text{Luas yang tidak terpakai}}{\text{Luas lembaran potong}} \text{x100\%} \quad \ldots (1)$$

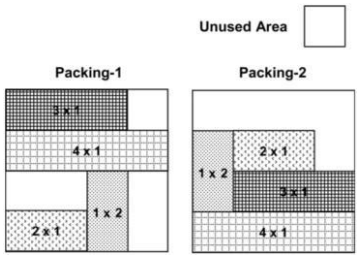


Figure 2. Two Cutting Pattern with Different Approach
Source : Goncalves, 2006

The equation which is developing in this research consider the probability of huge remaining extensive so that elimination of the biggest extensive are needed, so the equation (2) are generated. The constanta placement 0.03 can be learn in the journal [5]. The biggest ERS extensive which is calculated based extensive calculation from the difference of Ycorner with the raw material wide multiple by length of raw material.

$$\text{Modification \% Trim Loss (MTL)} = \text{\% Trim Loss} - 0.03 \times \frac{\text{Luas dari ERS terbesar}}{\text{Luas Lembaran Potong}} \times 100\% \quad \ldots\ldots (2)$$

The calculation result MTL_1 as much as 30.875% and MTL_2 as much as 30.5% on the Figure.2 gives a meaning that the equation result produces percentage score (2) created percentage score of remainig extensive less than equation (1)

Selection, Crossover, and Mutation

Selection which is applied in the genetic algorithm were done on three step, those are : developing sample space, sampling mechanism, probability sample. Sample space of new generation used generational replacement combination and elitis. Elitis which is applied is traditional elitis randomly generates the best chromosome gene with 15% from all chromosome parent gene. The aim of selection is to increase the solution which is given from old generation to new generation. Sampling mechanism which is done with roulette wheel to keep the survival probability of chromosome even though probability are depends on the fitness score that has been produced. Sampling probbaility which is done is scaling static to ensure the super chromosome does not dominate the population.

Crossover operator which is developed by applied parameterized unifrom crossover. The example of parameterized uniform crossover can be seen on the Figure.3. Parent chromosome which is selected from random score selection in the roulete wheel and others parent chromoseom was gotten from the best parent chromosome with 15% from all gene in the chromosome.

Chromosome 1	0.32	0.77	0.53	0.85
Chromosome 2	0.26	0.15	0.91	0.44
Rnd Number	0.58	0.89	0.68	0.25
Prob. Cross = 0.7	< 0.7	> 0.7	< 0.7	< 0.7
Offspring Chromosome	0.32	0.15	0.53	0.85

Figure 3. Calculation of Parameterized Uniform Crossover

Source : Goncalves, 2006

Mutation operator does not use the movement between gene with the level of mutation probability which is quite low. However, gene generation from chromosome parent were done randomly with 15% percentage from all the gene which is available. The aims of mutation is to prevent the formation of solution which is direct to center on the local optimal. The determination of selection parameter score as much as 15% probability crossover as much as 0,7, and the calculation constanta of trim loss equation are based on the trial result of journal experiment [5].

Website

Methode in developing website in this research is SDLC model development (System Developement Lyfe Cycle) or information system engineering with waterfall method.

Requiremenrs analysis and definition

The problem in this research is the form of waste in the process cutting industry because of cutting process that has not been optimal on the raw material sheet. So that, the demand analyst are needed to minimizing waste which occur in cutting process of raw materials to prevent the remaining cut which unable to use.

System and Software Design

Design interface interpretation which is prepared are follows :

- Interface Design
  Some design of parts are needed in the website to fullfill all the requirement to do calculation of cutting stock problem solver. The website design can be seen on the Figure.4.

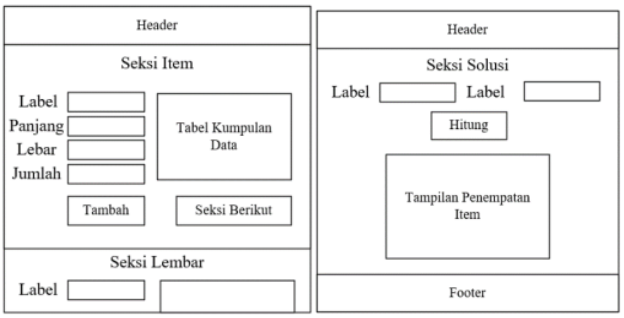


Figure 4. Website Interface Design

The website design based on data requirement are divided into 4 section, those are :

- First section (Homepage), a briefly explanation about website that will be developed
- Second section (Items Worksheet), a part for user input the data item which will be cut on the bigger sheet
- Third section (Stock Sheet Worksheet), a part for user to input the data sheet in one sheet
- Fourth section (Solution Worksheet), input the number of chromosome and gene which will be applied as parameter score in the genetic algorithm and calculation process, also final design of optimal cutting placement.
- Flowchart, can be sen on the Figure.5

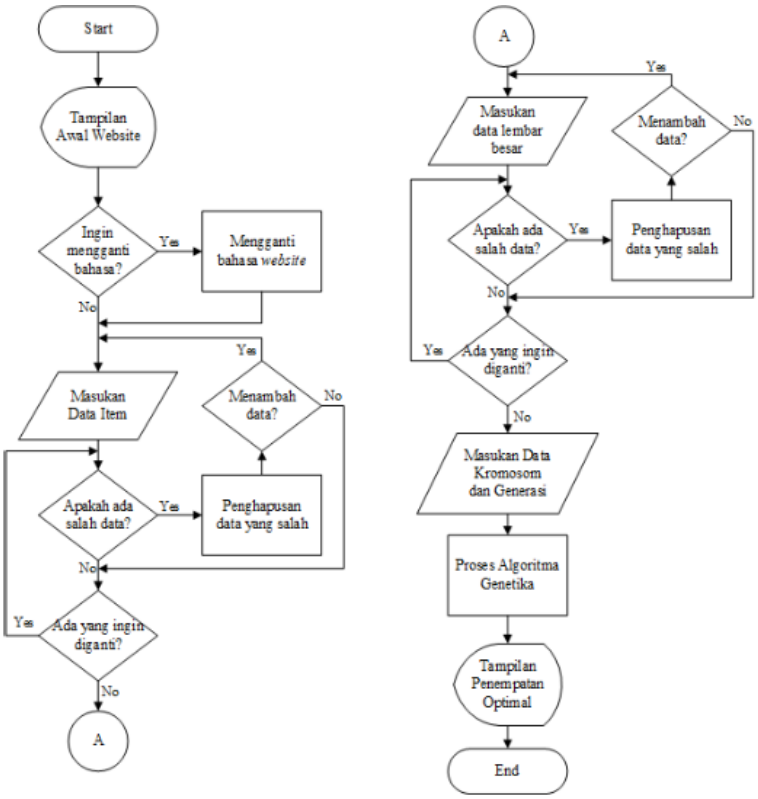
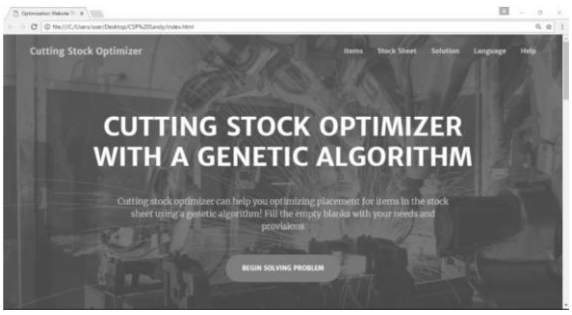


Figure 5. Flowchart Program

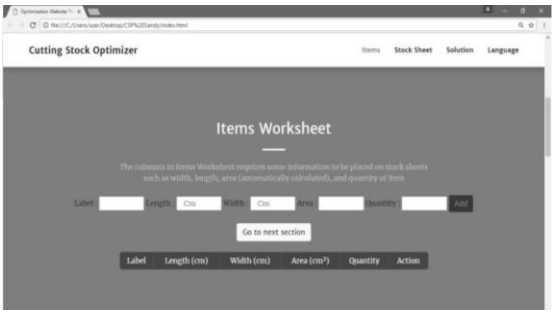
RESULT

Implementation Results

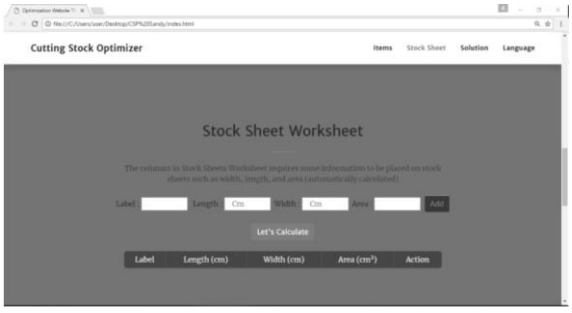
The implementation result from website developement in the problem solving of optimization can be seen on Figure.6.



(a)



(b)



(c)

(d)

Figure.6. a) homepage, b) items worksheet interface, c) stocksheet worksheet, d) solution workshee

Figure.6.a gives information about the illustration of all website which is used by user. There is a function for change the language to provide user needs such as website guideline. Picture 6b shown the second section to provide user data which will be cut on the raw material sheet. The data which is fullfilled by user will be shown in a table. Figure 6c shown the third section to provide the user data in the availability of raw material sheet. The material sheet become a placement to item position on the previous page which has been fullfilled by user. Data from user was filled in the table. Figure 6d shown the result part from genetic algorithm calculation which has been developed. The result is shown by picture with label on each item, and written on each product that has been placed in the raw material sheet.

Experiment Results

The validation of website will be done by comparing the actual result and the result on journal. The different between them will be outlined bellow. Level of confidence on the parameter calculation that will be achieved by researcher is 80%. The accuration optimal on calculation were taken by comparing the trim loss score in developed website in actual result.

The provement of website were done by using result and data on [11] and [1]. To produce a door will require view woods part which is taken from raw material with length 12 feet (3600 mm) and wide 55 mm. Table 2 is the data requirement of raw material by using 6 part of wood. However, due to the website that were made only accomodate a raw material sheet, so that the calculation process were merge for all the six part (Figure 7). There is also an example of placement experiment for each part of raw material on Figure 8.The result of placing which is given on figure 8 said that website are able to calculate the placement item on 1 dimension. The placement pattern that has been given is not suitable with pattern placement which is on the actual data because there is an effect of random number in algorythm to randomly the sorting item, nonetheless all item are succeed to be placed on each raw material sheet

The website provement that has been done on 2 dimension used the data and result which is provided on the [1]. The comparison of placing result on [1] and placing pattern which is calculated by website can be seen on Figure 8 and Figure 9. On instance 1, the fitness score which is generated by website as much as 14,1% and the score from journal as much as 14,2%. On instance 2, the fitness score that has been generated by website as much as 30,72% and the score on the journal is 31,03%. The smaller fitness score illustrates the pattern placement is more optimal. It can be concluded that the result of pattern placement which is taken by website gives the optimum pattern placement compare to pattern placement on journal [5].

Table 2. Calculation Data 1 Dimension

No	Object		Items			Waste
	Height	Length	Quantity	Height	Length	
1	55	3660	5	55	620	20
			1	55	540	
2	55	3660	4	55	625	0
			1	55	620	
			1	55	540	
3	55	3660	3	55	540	40
			1	55	2000	
4	55	3660	3	55	710	240
			1	55	2000	
5	55	3660	3	55	710	290
			2	55	620	
6	55	3660	1	55	2000	580
			2	55	540	

Type A : 2000 x 55 B : 710 x 55 C : 625 x 55 D : 620 x 55 E : 540 x 55

Figure 2. Result of Case Study by Website

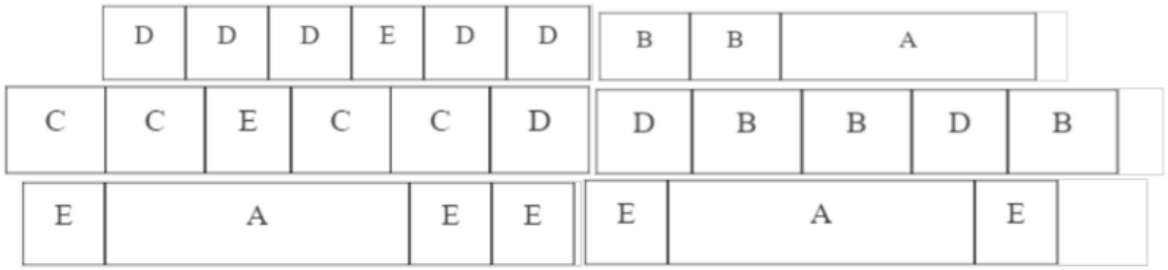
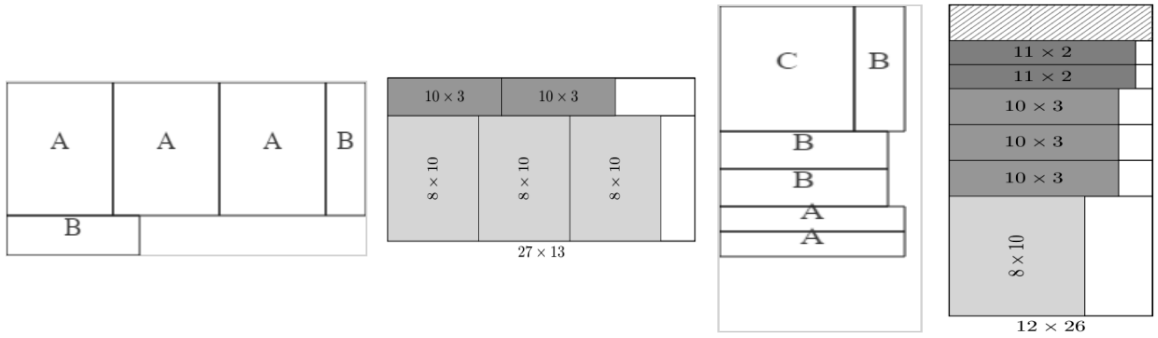


Figure 8. Result of Case Study each Raw Material Sheet

Table 3. Data Calculation 2 Dimension

Instance	Object		Items			
	Width	Height	Type	Quantity	Width	Height
1	27	13	A	3	8	10
			B	2	10	3
2	12	26	A	2	11	2
			B	3	10	3
			C	1	8	10



(a) (b)

Figure 9. a) Comparison Result of Placing Instance 1, b) Comparison Result of Placing Instance 2

CONCLUSIONS

Based on the research and developement of cutting optimization, can be concluded as follows :

1. Optimization website designed to make it easy for user in understanding the raw material pattern so that waste can be minimalized on cutting process 2 dimension and 1 dimension
2. This website has 4 main part, those are : homepage, part adding the data of user needs, part of adding the raw material data, and part of layout cutting result
3. The furniture, woods, iron, and enterpreneur are able to used the optimization website to help them determining the cutting layout
4. This website are still on developement with the drawing of cutting pattern more than a raw material sheet.

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