OPTIMIZATION *CUTTING STOCK* ONE DIMENSIONS ON INDUSTRY A WOODEN BEAM CUTTING WITH USE METHOD *COLUMN GENERATION TECHNIQUE*

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ABSTRACK: Cutting Stock Problem One Dimensions (CSP-1D) is a problem which managing timber cutting in order to minimize the residue result from the cuts and can form an optimal pattern cuts and to minimize the residue result from the cuts. This research performed using method Column Generation Technique and which the of software LINDO. The results showed that efficient use of wooden the optimization levels of 13,7% and profits from the rest of the cuts about 64,1%.
KEYWORD: Linear Programming, Cutting Stock, Column Generation Technique, LINDO.

1. INTRODUCTION

Indonesian is one of the state has forest area which vast expanse of and that is state important tropical round wooden, sawmill wood, plywood and wooden others. Production result Indoneslan's forest have *comparative advantage* if as compared with states the other and partly from result production in the forest will export to state the others. Other than wooden production too that is first devizen result from sector non oil and natural gas. Wood is one of result in forest which on process lacked for long time, until need of management the well, that is with pay attention system fell along with take ation against an primitive woodmen, in order to wood fullfilment in process the building, housing development and infrastructure the others unimpaired. Wooden company convert round wood be beams wood, or board. Then woods which beam wooden style, or board worked again be size certain appropriate with order of from owner offert wooden manufacturer (Supriyono, 2014).

One of problem optimization linier programming integer which any appear in sector industry such wooden industry is problem *Cutting Stock* One Dimension *(1D-CSP)*. Problem cutting stok one dimension that is problem where cutting pattern which used only use one kind cutting, that is lenght or width. In the wooden industry materials which use for production into circle style which lenght, example adaptable which lenght of the truck. For then, not always production which into kind the circle will direct use, but the wood will cutting equals with an consumer for help. Piece lenght which will request different with any piece result of different. For stoped out of account the circle which use, so the company can combination cutiing lenght for one of the circle which will use. Necessary for know combination of cutting size which want, and the company determine cutting size pattern which optimum can minimum cutting residue and any the circle which use (Sitohang, 2009).

PT. Bukit Intan Abadi Medan is one of company which product in sector industry beams wooden in Indonesian. PT. Bukit Intan Abadi Medan have consumer with the order which different in each and every city in North Sumatera. In fill order wood circle of order, consumer in the area and in any city in the North Sumatera, must a system minimum cutting stock in order that will be get profit very maximum. This is problem that is problem *cutting stock* and will solve with used *Column Generation Technique*.

Linear programming is a method will using in solve sollution problem optimization with panning steps which need with function getting optimum sollution, that is result of achieve to the function goodness range from to all result whichof possible. Any problem of solve used linear programming, other thing transportation problem, assignment problem, programa dinamic and programa integer. Liniar programming is the modle used for solved problem resource allocation definite with optimum. But, the sollution of result not integer, whereas any problem wanted for result of integer. Integer Programming is linear programming which result of sollution natural integer programming and compound integer programming . Integer programming can be solve with *branch and bound* method. In the solve linear programming problem, The method is using that is simplex method and revision simplex method (Saptadi , 2012).

J.Watson (2013) In the research which entitled multistage *cutting stock problems of two and more dimensions* can determine of optimization cutting combinatio n alternative and application a mathematical foundation for problem *Cutting Stock*. Hartono (2014) In the research about *Integer programming* with phenomenological *Branch and Bound* m e t h o d for optimization iron residue at floor. Permanasari (2006) in the research about Optimization *cutting stock* at industry letter cutting with used integer linear programming method, the modle make with 2 objective function that is minimum cutting residue for model I and maximum provit in for model II, however t h i s model problem two dimension. The technique others for solve problem cutting stock that is *Column Generation Technique*. One of aapplication from this technique that is for solve problem cutting stock one dimension *(1D-CSP)*.

2. RESEARCH METHOD

2.1 Population and research sample

Population extraction technique can do with criteria which used in population extraction is :

1. The company is industry business wooden beams piece.
2. Have kind wooden which used is kind wooden with quality kindly.
3. Have size data wooden beam piece one dimension
4. Have consumer order data at month January – Juny 2016.

Population in this research is consumer order data with size wooden beam piece with 5 kind wooden at January-Juny 2016. Building on criteria sample selection, get consumer ordered data with kind Rubber Wood wooden at Juny 2016.

Table 4.1. Pattern wooden beam cut

Genre	**Pattern** (x_i)	**lenght**	**Lenght type** (c_j)		
Wood		**(meter)**	**26**	**31**	**44**
Rubber Wood	1	2,5	0	2	4
Rubber Wood	2	2,5	0	0	5
Rubber Wood	3	2,5	1	4	2
Rubber Wood	4	2,5	0	8	0
Rubber Wood	5	2,5	2	3	2
Rubber Wood	6	2,5	2	2	3
Rubber Wood	7	2,5	3	1	3
Rubber Wood	8	2,5	3	4	1
Rubber Wood	9	2,5	6	0	2
Rubber Wood	10	2,5	8	1	0
Rubber Wood	11	2,5	4	3	1
Rubber Wood	12	2,5	4	1	2
Rubber Wood	13	2,5	6	3	0
Rubber Wood	14	2,5	4	4	0
Rubber Wood	15	2,5	9	0	0
Rubber Wood	16	2,5	0	3	3
Rubber Wood	17	2,5	1	5	1
Rubber Wood	18	2,5	0	5	2
Rubber Wood	19	2,5	0	2	4
Rubber Wood	20	2,5	1	1	4

Business data result 244 stem size 26 cm , 415 stem size 31 cm and 4674 stem size 44 cm.

2.2 Reasearch Prosedure

1. Data Raising

This research used quantitative data is data which shaped numeral which will process for know piece optimize. Data which used in this research used secondary data, that is primery data which process previous by first side with process primery data which get then show for used by side second. Aggregation technique can be used way documentation or aggregation data can be with way execute interview with one of company side after that can see documentation so as to can be get data which want.

2. Data Analysis

Steps which the worked that is:

1. Formulation problem into linier programming.
   a. Product lenght size *L*.
   b. Piece residue *s* with pattern *j*.
   c. pattern piece *j* where $j = 1,2,\dots,m$.
   d. Make *objective function*.
      Minimum piece residue, as equality :
      Min $z(x_j) = \sum_{j=1}^{n} c_j x_j$
      Where c_j is many account wooden beam which the order according to pattern *j* and $j = 1,2,\dots,m$ and x_j is account wooden beam lenght *L* meter which piece according to pattern *j* and $j = 1,2,\dots,m$.
   e. Make subject to for minimum model as equality :
      $$\sum_{j=1}^{n} a_{ij} x_{ij}$$
      Where a_{ij} is coefficients from variable x_{ij} which assumption as many order according to pattern *j* and $j = 1,2,\dots,m$ and x_{ij} is account wooden beam lenght *L* meter which piece according to pattern *j* and $j = 1,2,\dots,m$.
2. Convert into linear programming be canonical.
3. The count $B_0{}^{-1}$ and $c_{VB}B_0{}^{-1}$.
4. Look for price out efficient pattern. For price efficient pattern, as equality:

Maximum $w(y_j) = \sum_{j=1}^{n} \pi_t y_j - 1$

Subject to :

$$\sum_{j=1}^{n} K_i y_j \leq L$$

$y_j \geq 0$ and integer

$j = 1,2,\dots,n$ and $i = 1,2,\dots,m$.

   a. Determine ratio and rank.
   b. Solve *Branch and Bound* method.
5. Solve optimum sollution value.
6. Determine new variable which will be basis variable.
7. Solve $B_1{}^{-1}$ and $c_{VB}B_1{}^{-1}$.
   a. Determine ratio and rank.
   b. Solve *Branch and Bound* method.
8. Determine basis variable value at optimum sollution.
9. Solve problem with used software LINDO.

3 RESULT AND DISCUSSION

Steps *Column Generation Technique* according Gamal and Bahri (2003) is:

1. Formulation problem into linear programming

MIN $z = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + \cdots + x_{20}$

Subject to :

$x_3 + 2x_5 + 2x_6 + 3x_7 + 3x_8 + 6x_9 + 8x_{10} + 4x_{11} + 4x_{12} + 6x_{13} + 4x_{14} + 9x_{15} + x_{17} + x_{20} \geq 244$

$2x_1 + 4x_3 + 8x_4 + 3x_5 + 2x_6 + x_7 + 4x_8 + x_{10} + 3x_{11} + 2x_{12} + 3x_{16} + 5x_{17} + 5x_{18} + 2x_{19} + x_{20} \geq 415$

$$4x_1 + 5x_3 + 2x_3 + 2x_5 + 3x_6 + 3x_7 + x_8 + 2x_9 + x_{11} + 2x_{12} + 3x_{16} + x_{17} + 2x_{18} + 4x_{19} + 4x_{20} \geq 4674$$

$x_j \geq 0 ; j = 1,2, \ldots, 20$ and integer.

From in the equality, the canonical can $VB = \{x_2, x_4, x_{15}\}$ and $VNB = \{x_1, x_3, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, \ldots, x_{20}\}$.

2. The figured B_0^{-1} and $c_{VB}B_0^{-1}$

$$B_0 = \begin{bmatrix} 5 & 0 & 0 \\ 0 & 8 & 0 \\ 0 & 0 & 9 \end{bmatrix}, \qquad B_0^{-1} = \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & \frac{1}{9} \end{bmatrix}$$

So,

$$c_{VB}B_0^{-1} = [1 \;\; 1 \;\; 1] \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & \frac{1}{9} \end{bmatrix} = \left[\frac{1}{5} \frac{1}{8} \frac{1}{9}\right]$$

For basis different from others, a pattern finding by y_1, y_2 dan y_3 will be value $z_j - c_j$:

$$z_j - c_j = c_{VB}B^{-1} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} - 1 = \frac{1}{5}y_1 + \frac{1}{8}y_2 + \frac{1}{9}y_3 - 1$$

3. Look for price out efficient pattern.

$$\text{Maximum } w(y_1, y_2, y_3) = \frac{1}{5}y_1 + \frac{1}{8}y_2 + \frac{1}{9}y_3 - 1$$

Subject to :

$$44y_1 + 31y_2 + 26y_3 \leq 250$$

$y_1, y_2, y_3 \geq 0$ and integer.

With method *branch and bound* and used software LINDO can be value $y_1 = 5$, $y_2 = 0$ and $y_3 = 1$

4. Optimum price for problem *knapsack* upper shape new pattern be said to be pattern 21. So, value $z_{21} - c_{21}$ is 0,11, and with substitution x_{21} in the basis will residue decreasing wood beams cutting.
5. Determine nonbasis variable which will be basis variable:

$$B_0^{-1} \begin{bmatrix} 5 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & \frac{1}{9} \end{bmatrix} \begin{bmatrix} 5 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ \frac{1}{9} \end{bmatrix}$$

$$B_1^{-1} = \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$c_{VB}B^{-1} = [1 \;\; 1 \;\; 1] \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & 1 \end{bmatrix} = \left[\frac{1}{5} \frac{1}{8} 0\right]$$

$$z_j - c_j = \frac{1}{5}y_1 + \frac{1}{8}y_2 - 1$$

results *knapsack* problem:

$$\text{Maximum } w(y_1, y_2) \frac{1}{5}y_1 + \frac{1}{8}y_2 - 1$$

Subject to,

$$44y_1 + 31y_2 \leq 250$$

$y_1, y_2 \geq 0$ dan bilangan bulat.

With *Branch and Bound* Method can be:

$$y_1 = 5, \quad y_2 = 0 \text{ and } y_3 = 0$$

For can basis variable values VB(1) at optimum sollution searchable value part right is:

$$B_1{}^{-1}b = \begin{bmatrix} \frac{1}{5} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4674 \\ 415 \\ 244 \end{bmatrix} = \begin{bmatrix} 690{,}8 \\ 51{,}875 \\ 244 \end{bmatrix}$$

So, Optimum sollution for problem at wood beam cutting given that:

$$x_2 = 690{,}8 \ , \quad x_4 = 51{,}875 \text{ and } x_{21} = 244$$

For can a feasible sollution integer so, make with way upper round x_2 and x_{15} values, until will the result integer sollution.

$$x_2 = 691 \ , \quad x_4 = 52 \text{ and } x_{21} = 244$$

So, consumer order is as many 691 stem with long 44 cm, 51 stem with long 31 cm and 244 stem with long 44 cm and 26 cm can a condition by wooden company with piece wood beam lenght 2,5 meter as many 691 stem the piece used pattern 2, 52 stem piece used pattern 4 and 244 stem piece used 21 pattern. With *column generation technique*, amount piece which getting by company for fulfill order is:

a. Pattern 2 can be 5 piece wooden beam with lenght 44 cm.
b. Pattern 4 can be 8 piece wooden beam with lenght 26 cm
c. Pattern 21 can be 1 piece wooden beam with lenght 26 cm and wooden beam with lenght 44 cm.

4 CONCLUSION AND SUGGESTION

4.1 CONCLUSION

From result and consideration with used *Column Generation Technique* inferential about for minimum piece residue, PT. Bukit Intan Abadi Medan can be cutting 2,5 meter lenght wooden beam as many 987 stem which get as many 5335, with production surplus lenght 31cm as many 1 stem and lenght 44cm as many 1 stem.

4.2 SUGGESTION

a. For study others from implementation *Column Generation Technique* is at cutting problem two dimension or three dimension.
b. For problem others *Column Generation Technique* can be implementation at problem *Dekomposisi Dantziq-Wolfe* method.

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