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Trim Loss Minimization and Reel Cutting at Paper Mill

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Abstract: This work aims to solve a real-world industrial problem of trim loss minimization that a paper mill in Peshawar encounters on regular basis. The mill produces master paper reels of a standard width. The orders received are for smaller widths called auxiliary widths. The objective is to meet the order using minimum possible number of master reels. The study begins with determination of the width combinations of auxiliary reels of different widths. The width combination process determines the quantity and cutting patterns of reels of required sizes in a manner that minimizes trim losses while satisfying production orders. The problem is solved in two phases. The first phase is based on Simplex Method that generally leads to non-integer solution. The second phase uses binary programming in order to determine an integer solution. The program is coded in MATLAB. Details of the models, solution methods and illustrative computational results are included.

Keywords: Trim Loss, Simplex Method, Optimal Solution, Binary Programming, Stepwise Approach

I. INTRODUCTION

This paper deals with cutting stock problem that arises in a make-to-order paper production mill. Orders are accepted from customers and planning and production are accomplished within due time. Before the implementation of our system, planning was done manually by a team of managers and schedulers over many hours. The objective is to evaluate an optimal solution to cut master reels of standard width into auxiliary reels of smaller widths in a manner to satisfy a set of customers' demand with minimum possible waste.

The work presented is mainly concerned with the cutting patterns generation process which determines the quantity of master reels to produce in order to minimize waste while satisfying a production order. We have also incorporated the use of already available pieces in stock thereby further improving the solution. Another feature of our approach is to incorporate a limit in the number of cutting blades at winder for cutting the master reel into auxiliary reels of required widths simultaneously. Some constraints must be imposed during the determination of the cutting patterns to associate to a master reel. The procedure developed determines the required meaningful feasible combinations of widths with a minimal waste production or trim loss.

The production of paper at mill requires different mathematical and programming formulations and solution methods. Minimizing setup time and trim loss are usually the components of the objective function [1],[3]. The procedure developed disregards trim loss at the two ends of the master reel. Besides paper industry, similar approaches are also applied in other industries such as textile, steel, fiber and plastic industries [2]. We have to produce sufficient number of master reels of width *W*, and cut auxiliary reels of different widths $w_1, w_2, ..., w_m$ according to demands $d_1, d_2, ..., d_m$. Gilmore and Gomory [4],[5] presented an approach to evaluate cutting patterns necessary to improve and optimize the LP solution. There are many ways to cut a master reel into auxiliary reels of smaller widths. A feasible combination of widths have sum of required widths less than the width of master reel and have trim loss less than the smallest required width. Any surplus production of required widths' reels is considered as trim loss area [13].

The problem studied in this paper is related to the determination of all the meaningful combinations of required widths and number of auxiliary reels to produce in order to satisfy a set of customers' orders. Various industrial constraints are involved and studied in the planning and operating processes. The procedure developed leads to considerable improvement in terms of trim loss minimization and number of setups. The solution procedure is based on linear programming model which is solved by the Simplex algorithm. The solution obtained (if non-integer) is converted into integer solution in the second phase of the solution. MATLAB predefined functions and formulae are used to achieve the required final integer optimal solution.

II. MATHEMATICAL MODELING

The standard formulation for the cutting stock problem starts with master reels of widths $W_1, W_2, ..., W_k$ with m orders of auxiliary reels of widths $w_1, w_2, ..., w_m$ each with corresponding demands $d_1, d_2, ..., d_m$. We then construct a list of all meaningful feasible combinations of cuts associating with each pattern (a feasible combination of required widths). The frequencies of each required width of the auxiliary reels in a pattern is evaluated and is put as coefficients of the variables in the left hand side of the inequality constraints. The demands $d_1, d_2, ..., d_m$ are put in the right hand side of the inequality constraints and the sign ≥ (greater than or equal) is put between the left and right hand sides of the inequality constraints. Here j is the maximum number of meaningful feasible combinations of master reel of width W. The objective of minimizing the trim loss reduces to minimizing $X_1 + X_2 + ... + X_a$. The linear integer programming problem is then:

Minimize: $\sum_{a=1}^{j} X_a$

Subject to: $\sum_{a=1}^{j} f_{i,a} X_a \geq d_i \qquad i = 1,2,\ldots,m$

and $X_a \geq 0$, integer

Here $f_{i,a}$ is the number of times an order i appears in a feasible combination X_a of a master reel of standard width W.

If there are reels present at stock of single width w'_1 and N_1 be the total number of stocked reels of width w'_1, then the problem formulation takes the form:

Minimize: $W\sum_{a=1}^{j} X_a + w'_1 \sum_{b=j+1}^{k} X_b$

Subject to: $\sum_{a=1}^{j} f_{i,a} X_a + \sum_{b=j+1}^{k} f_{i,b} X_b \geq d_i \qquad i = 1,2,\ldots,m$

$\sum_{b=j+1}^{k} X_b \leq N_1$

and $X_a, X_b \geq 0$, integers

Similarly here, $f_{i,b}$ is the frequency of required width of an order i in a feasible combination X_b of the stocked reels of width w'_1. The constraint $\sum_{b=j+1}^{k} X_b \leq N_1$ is added for stocked reels of width w'_1.

The problem is solved by Simplex algorithm. The positive integer variables X_a and X_b represent the number of times each pattern is to be used. A separate algorithm (Phase-II) is solved to make the solution integer if the initially obtained optimal solution of Phase-I has more than a single non-integer values of the patterns X_a and X_b.

III. PROBLEM DESCRIPTION

In a paper mill, a set of demands composed of variable reel quantities and width sizes, is met by cutting a master reel produced by paper machines. The problem studied in this paper is related to find the meaningful feasible combinations of widths in order to minimize trim loss and provide stocked reels to the customers. A feasible combination is termed as meaningful if the corresponding trim loss is less than the minimum required width in a set of orders and sum of auxiliary reels' widths in a combination not exceeds the width of master reel. In a feasible combination of widths, if the sum of widths is cut from the total width of master reel, the remaining portion is termed as trim loss. Customer required width must not exceed the total width of master reel.

Suppose we have customers' demand of two reels of width 4 meters and two reels of width 3 meters. The paper mill is producing unlimited master reels of width 5 meters and only two stocked reels of width 4 meters are available. Fig.1 shows the optimal solution:

Table I: *Customers' demand*

Required widths	***Minimum number of reels required***
3	2
4	2

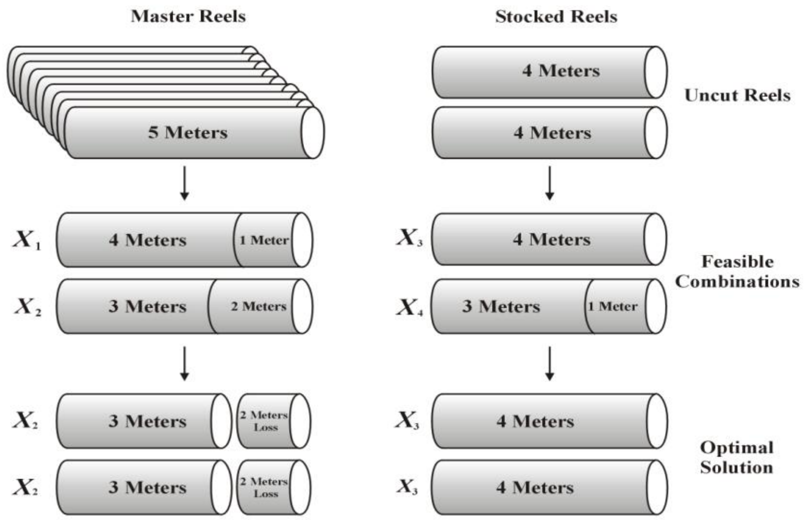

Fig.1 *Assignment of orders*

The limitation of cutting blades during cutting of reels is also incorporated. If we have to cut a master reel into three auxiliary reels simultaneously then it needs two cutting blades to perform this operation except the two cutting blades at extremes for achieving smooth edges of master reel. If we have to cut a master reel into two auxiliary reels simultaneously then only one cutting blade is needed and if the cutting blades are available more than the required then extra blades are made non-operational.

Fig.2 *Cutting blades at the winder*

IV. ILLUSTRATION AND SOLUTION PROCEDURE OF ONE-DIEMENSIONAL CUTTING STOCK PROBLEM

Phase-I

A paper machine produces an unlimited number of master reels of widths $W_1, W_2, ..., W_k$ each having length L. Orders for demands d_i with corresponding widths w_i for $i = 1, 2, \ldots, m$ must be met by cutting the master reels into auxiliary reels. The total area of order is then $L \sum_{i=1}^{m} w_i d_i$. Each feasible combination of the required widths $w_1, w_2, ..., w_m$ for width W of a specific master reel is considered a separate variable and is assigned variable name X_a. There may also be some auxiliary reels present at stock and can be utilized for meeting demands. The widths and number of auxiliary reels available at stock are tabled below.

Table II: *Widths and number of stocked reels*

Widths of stocked reels	***Number of stocked reels***
w'_1	N_1
w'_2	N_2
$\vdots$	$\vdots$
w'_n	N_n

All the meaningful feasible combinations of required widths $w_1, w_2, ..., w_m$ associated with width *W* of the master reel are:

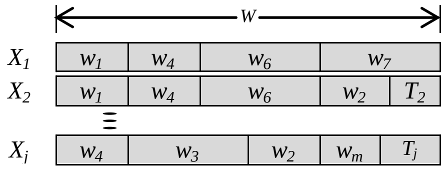

Fig.3 *Feasible combinations of required widths associated with master reel of width W*

Similar meaningful feasible combinations are formed for the stocked reels of widths $w'_1, w'_2, ..., w'_n$.

Let there be two reels of different smaller widths w'_1 and w'_2 present at stock and N_1 and N_2 be the number of stocked reels available respectively. All the meaningful feasible combinations of W are $X_1, X_2, ..., X_j$ and those of w'_1 and w'_2 are $X_{j+1}, X_{j+2}, ..., X_k$ and $X_{k+1}, X_{k+2}, ..., X_p$ respectively.

Table III: *Knife settings associated with master reel and stocked reels*

		Knife Setting for W				***Knife Setting for*** w'_1				***Knife Setting for*** w'_2				
		X_1	X_2	$\cdots$	X_j	X_{j+1}	X_{j+2}	$\cdots$	X_k	X_{k+1}	X_{k+2}	$\cdots$	X_p	*Minimum number of reels required*
Required Widths	w_1	$f_{1,1}$	$f_{1,2}$	$\cdots$	$f_{1,j}$	$f_{1,j+1}$	$f_{1,j+2}$	$\cdots$	$f_{1,k}$	$f_{1,k+1}$	$f_{1,k+2}$	$\cdots$	$f_{1,p}$	d_1
	w_2	$f_{2,1}$	$f_{2,2}$	$\cdots$	$f_{2,j}$	$f_{2,j+1}$	$f_{2,j+2}$	$\cdots$	$f_{2,k}$	$f_{2,k+1}$	$f_{2,k+2}$	$\cdots$	$f_{2,p}$	d_2
	$\vdots$	$\vdots$	$\vdots$	$\vdots\ \vdots\ \vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots\ \vdots\ \vdots$	$\vdots$	$\vdots$
	w_m	$f_{m,1}$	$f_{m,2}$	$\cdots$	$f_{m,j}$	$f_{m,j+1}$	$f_{m,j+2}$		$f_{m,k}$	$f_{m,k+1}$	$f_{m,k+2}$	$\cdots$	$f_{m,p}$	d_m
	Losses	T_1	T_2	$\cdots$	T_j	T_{j+1}	T_{j+2}	$\cdots$	T_k	T_{k+1}	T_{k+2}	$\cdots$	T_p	

The objective of this problem is to minimize trim loss, which can be shown to be:

Minimize: $$Z = W\sum_{a=1}^{j} X_a + w'_1 \sum_{b=j+1}^{k} X_b + w'_2 \sum_{c=k+1}^{p} X_c$$

Subject to: $$\sum_{a=1}^{j} f_{m,a} X_a + \sum_{b=j+1}^{k} f_{m,b} X_b + \sum_{c=k+1}^{p} f_{m,c} X_c \geq d_m$$

$$\sum_{b=j+1}^{k} X_b \leq N_1$$

$$\sum_{c=k+1}^{p} X_c \leq N_2$$

and $X_j, X_k, X_p \geq 0$, integers

The last two constraints $\sum_{b=j+1}^{k} X_b \leq N_1$ and $\sum_{c=k+1}^{p} X_c \leq N_2$ are added, imposing maximum limit on the number of available stock reels of widths w'_1 and w'_2 respectively. Here $f_{m,a}$ is the number of times an order m appears in a pattern X_a associated with master reel of width W. Similarly $f_{m,b}$ and $f_{m,c}$ is the number of times an order m appears in the patterns X_b and X_c of stocked reels of widths w'_1 and w'_2 respectively.

The problem is solved using Simplex algorithm and cutting the number of standard reels according to a given setting is evaluated. The positive integer variables X_a, X_b and X_c represent how many times each pattern is to be used. The optimal solution of Phase-I takes the form:

$$
\begin{array}{lll}
X_1 = \lambda_1 + 0 & X_{j+1} = \lambda_{j+1} + 0 & X_{k+1} = \lambda_{k+1} + 0 \\
X_2 = \lambda_2 + \mu_2 & X_{j+2} = \lambda_{j+2} + \mu_{j+2} & X_{k+2} = \lambda_{k+2} + \mu_{k+2} \\
\vdots & \vdots & \vdots \\
X_j = \lambda_j + \mu_j & X_k = \lambda_k + 0 & X_p = \lambda_p + 0
\end{array}
$$

Here, λ_j is the integer part of the solution while μ_j is the fractional part.

If all the variables X_a, X_b and X_c in the optimal solution of Phase-I result in integer values then there is no need to solve Phase-II. The optimal solution of Phase-I is considered as the final optimal solution.

Phase-II

In Phase-II, we consider only the integer parts of the solution found through Simplex method and figure out the remaining demands yet to meet using binary variables. The objective remains the same while the constraints are formulated for the unmet demands. The optimal solution of the Phase-II is added to the corresponding integer parts of the solution of Phase-I to obtain the overall final optimal solution. The integer parts of the non-integer variables in the optimal solution of Phase-I are:

$$
\begin{array}{lll}
X_2 = \lambda_2 & X_{j+2} = \lambda_{j+2} & X_{k+2} = \lambda_{k+2} \\
X_j = \lambda_j & X_{j+3} = \lambda_{j+3} & X_{k+3} = \lambda_{k+3}
\end{array}
$$

Table IV: *Widths' frequencies in feasible combinations*

		Knife Setting for W				***Knife Setting for w'_1***				***Knife Setting for w'_2***			
		X_1	X_2	$\cdots$	X_j	X_{j+1}	X_{j+2}	$\cdots$	X_k	X_{k+1}	X_{k+2}	$\cdots$	X_p
Required Widths	w_1	$f_{1,1}$	$f_{1,2}$	$\cdots$	$f_{1,j}$	$f_{1,j+1}$	$f_{1,j+2}$	$\cdots$	$f_{1,k}$	$f_{1,k+1}$	$f_{1,k+2}$	$\cdots$	$f_{1,p}$
	w_2	$f_{2,1}$	$f_{2,2}$	$\cdots$	$f_{2,j}$	$f_{2,j+1}$	$f_{2,j+2}$	$\cdots$	$f_{2,k}$	$f_{2,k+1}$	$f_{2,k+2}$	$\cdots$	$f_{2,p}$
	$\vdots$	$\vdots$	$\vdots$	$\vdots\ \vdots\ \vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots\ \vdots\ \vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots\ \vdots\ \vdots$	$\vdots$
	w_m	$f_{m,1}$	$f_{m,2}$	$\cdots$	$f_{m,j}$	$f_{m,j+1}$	$f_{m,j+2}$	$\cdots$	$f_{m,k}$	$f_{m,k+1}$	$f_{m,k+2}$	$\cdots$	$f_{m,p}$

Table V: *Part of the solution before decimal*

Setting	X_1	X_2	$\dots$	X_j	X_{j+1}	X_{j+2}	$\dots$	X_k	X_{k+1}	X_{k+2}	$\dots$	X_p
Part of the solution before decimal	λ_1	λ_2	$\dots$	λ_j	λ_{j+1}	λ_{j+2}	$\dots$	λ_k	λ_{k+1}	λ_{k+2}	$\dots$	λ_p

Considering the frequency values in ***Table IV*** and values of variables in ***Table V*** as two separate matrices and then multiplying, the result is matrix C.

Table VI: *Shortages' Evaluation*

Required Widths	***Required number of reels***	***Matrix C***	***Shortages***	***Excess***
w_1	d_1	$C_1=d_1-1$	$S_1=1$	$E_1=0$
w_2	d_2	$C_2=d_2-3$	$S_2=3$	$E_2=0$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
w_m	d_m	$C_m=d_m+25$	$S_m=0$	$E_m=25$

The excess amount of reels produced is stocked and is provided upon demand.

Considering only the frequency values of $X_2, X_j, X_{j+2}, X_{j+3}, X_{k+2}$ and X_{k+3} (non-integers in the optimal solution) form ***Table IV.***

Table VII: *Frequency values of non-integer variables in the optimal solution*

		Non-integers in optimal solution						
		X_2	X_j	X_{j+2}	X_{j+3}	X_{k+2}	X_{k+3}	**Shortages**
Required Widths	w_1	$f_{1,2}$	$f_{1,j}$	$f_{1,j+2}$	$f_{1,j+3}$	$f_{1,k+2}$	$f_{1,k+3}$	S_1
	w_2	$f_{2,2}$	$f_{2,j}$	$f_{2,j+2}$	$f_{2,j+3}$	$f_{2,k+2}$	$f_{2,k+3}$	S_2
	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	w_m	$f_{m,2}$	$f_{m,j}$	$f_{m,j+2}$	$f_{m,j+3}$	$f_{m,k+2}$	$f_{m,k+3}$	S_m

The objective to solve Phase-II for binary answers is:

Minimize: $Z = X_2 + X_j + X_{j+2} + X_{j+3} + X_{k+2} + X_{k+3}$

Subject to:

$$f_{1,2}X_2 + f_{1,j}X_j + f_{1,j+2}X_{j+2} + f_{1,j+3}X_{j+3} + f_{1,k+2}X_{k+2} + f_{1,k+3}X_{k+3} \geq S_1 \quad \text{for} \quad m = 1$$

Similar constraints are constructed for $m = 2,3$ and so on.

The binary answers are:

$$X_2 = \lambda'_2 \qquad X_{j+2} = \lambda'_{j+2} \qquad X_{k+2} = \lambda'_{k+2}$$
$$X_j = \lambda'_j \qquad X_{j+3} = \lambda'_{j+3} \qquad X_{k+3} = \lambda'_{k+3}$$

Final optimal integer solution is:

$$X_1 = \lambda_1 \qquad X_{j+1} = \lambda_{j+1} \qquad X_{k+1} = \lambda_{k+1}$$
$$X_2 = \lambda_2 + \lambda'_2 \qquad X_{j+2} = \lambda_{j+2} + \lambda'_{j+2} \qquad X_{k+2} = \lambda_{k+2} + \lambda'_{k+2}$$
$$\vdots \qquad \vdots \qquad \vdots$$
$$X_j = \lambda_j + \lambda'_j \qquad X_k = \lambda_k \qquad X_p = \lambda_p$$

Total area of an order = $L\sum_{i=1}^{m} w_i\, d_i$

Total area of the selected patterns = $(W\sum_{a=1}^{j} X_a + w'_1\sum_{b=j+1}^{k} X_b + w'_2\sum_{c=k+1}^{p} X_c) \times L$

If master reel and stocked reels have different lengths, then

Total area of the selected patterns = $WL\sum_{a=1}^{j} X_a + w'_1 L_1\sum_{b=j+1}^{k} X_b + w'_2 L_2\sum_{c=k+1}^{p} X_c$

Total useful area of reels produced for an order = $[\sum_{a=1}^{j}\{X_a(W - T_a)\} + \sum_{b=j+1}^{k}\{X_b(w'_1 - T_b)\} + \sum_{c=k+1}^{p}\{X_c(w'_2 - T_c)\}] \times L$

Area of reels stocked after marketing an order = Total useful area of reels produced for an order-Total area of an order

Trim Loss = Total area of the selected patters - Total useful area of reels produced for an order

V. ILLUSTRATIVE FLOWCHART FOR MATLAB CODING

A stepwise approach is adopted and the procedure developed is coded in MATLAB. The flowchart shows various steps to solve the problem.

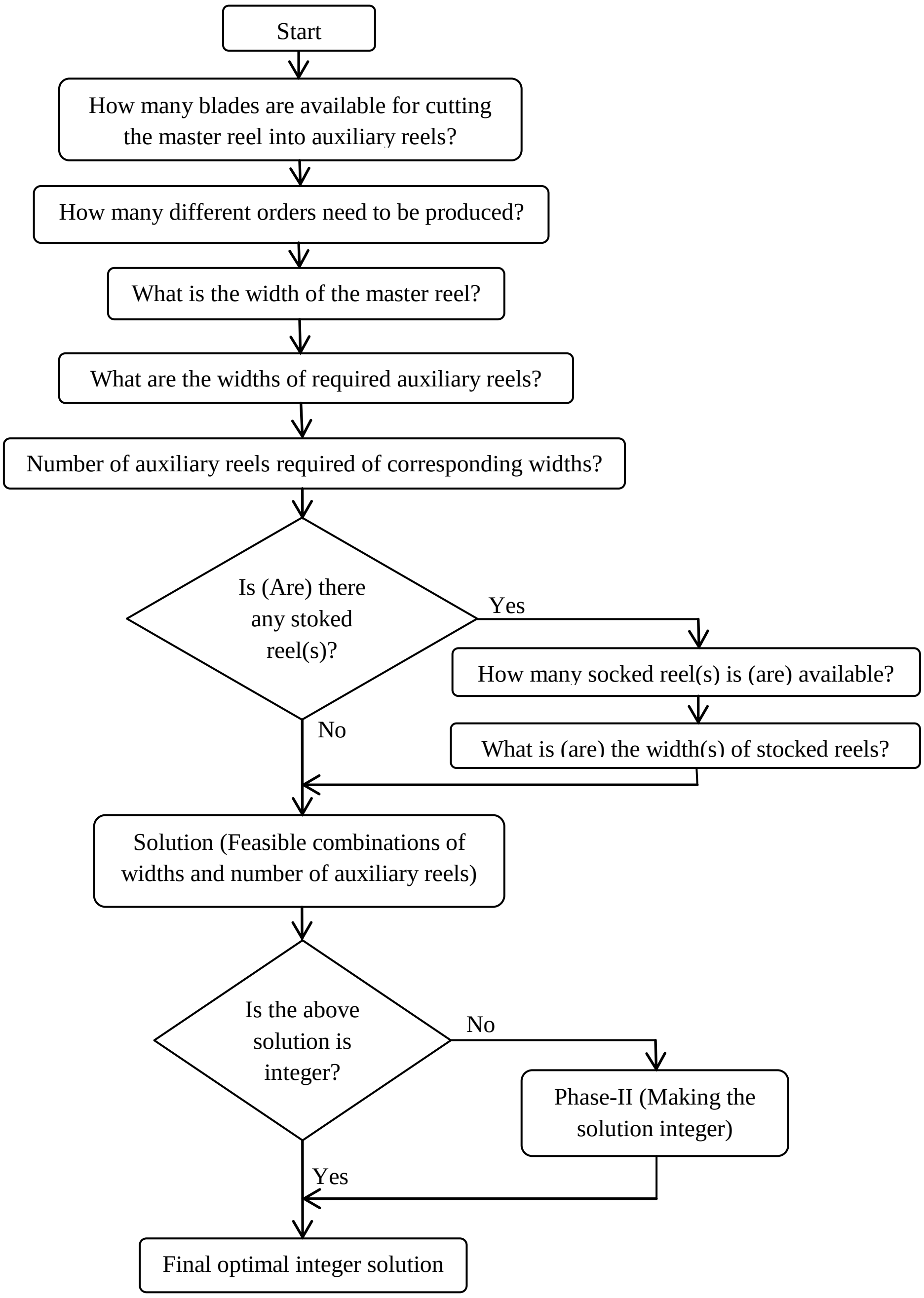

Fig. 4 *Illustrative flowchart for MATLAB coding*

VI. EXAMPLE

(All dimensions measured in inches)

Phase-I

A paper machine produces an unlimited number of master reels of standard width 20. The cutting blades available at the winder are 5. The demand from customers and available stocked reels are:

Table VIII: *Customers' Demand*

Required widths	*Minimum number of reels required*
5	50
6	70

Table IX: *Widths and number of stocked reels*

Widths of stocked reels	*Maximum number of stocked reels available*
10	40
9	30
8	50

All the meaningful feasible combinations of required widths associated with width 20 of the master reel are:

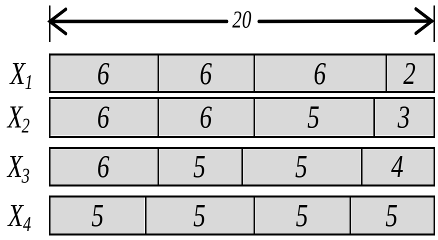

Fig.5 *Feasible combinations of required widths*

Three cutting blades are required to cut the master reels and auxiliary reels into smaller reels of required widths at winder. In this example, more than three blades are available at winder. The extra two available blades are made non-operational. All the meaningful feasible combinations of required widths for the widths 10, 9 and 8 of the stocked reel are:

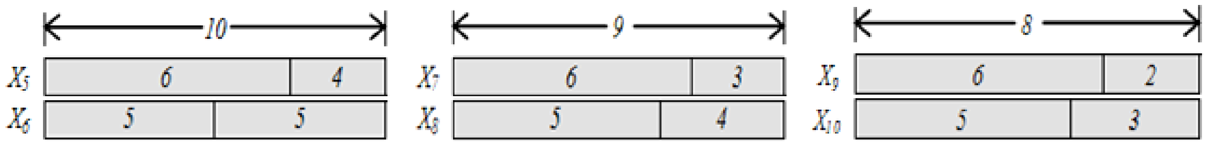

Fig.6 *Feasible combinations of required widths for stocked reels*

Considering $W = 20$, $w'_1 = 10$, $w'_2 = 9$ and $w'_3 = 8$. The knife setting table shows the coefficients of the variables in the inequality constraints.

Table X: *Knife settings of master reels and stocked reels*

		Knife Setting for W				***Knife Setting for w'_1***		***Knife Setting for w'_2***		***Knife Setting for w'_3***		
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	***Minimum desired number of auxiliary reels***
Required Widths	5	0	1	2	4	0	2	0	1	0	1	50
	6	3	2	1	0	1	0	1	0	1	0	70
	Trim Loss	2	3	4	0	4	0	3	4	2	3	

The objective is to minimize trim loss which reduces to:

Minimize: $Z = 20(X_1 + X_2 + X_3 + X_4) + 10(X_5 + X_6) + 9(X_7 + X_8) + 8(X_9 + X_{10})$

Subject to:

$$X_2 + 2X_3 + 4X_4 + 2X_6 + X_8 + X_{10} \geq 50$$
$$3X_1 + 2X_2 + X_3 + X_5 + X_7 + X_9 \geq 70$$
$$X_5 + X_6 \leq 40$$
$$X_7 + X_8 \leq 30$$
$$X_9 + X_{10} \leq 50$$

Solving the above constraints by Simplex algorithm, the optimal solution of the Phase-I of the problem is:

$$X_1 = 23.33$$
$$X_4 = 12.50$$

In this case, there are two non-integer variables in the optimal solution of Phase-I. Phase-II is solved for integer solution.

<u>Phase-II</u>

In Phase-II, only the integer parts are considered of the solution found through Simplex method in Phase-I. The objective of minimizing trim loss remains the same. The constraints are constructed for the unmet demands. Considering only the integer parts of the variables X_1 and X_4.

$$X_1 = 23$$
$$X_4 = 12$$

To solve the problem for integer solution, considering the coefficients of the variables in the inequality constraints:

Table XI: *Coefficients of the variables in the inequality constraints*

		Knife Setting for W				***Knife Setting for*** w'_1		***Knife Setting for*** w'_2		***Knife Setting for*** w'_3	
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Required Widths	5	0	1	2	4	0	2	0	1	0	1
	6	3	2	1	0	1	0	1	0	1	0

Table XII: *Integer parts of the solution obtained in Phase-I*

Variables	***Integer part of the variables***
X_1	23
X_2	0
X_3	0
X_4	12
X_5	0
X_6	0
X_7	0
X_8	0
X_9	0
X_{10}	0

Taking the coefficients of variables in the in the inequality constraints from ***Table XI*** *as matrix A, and those of* ***Table XII*** *as matrix B. Multiplying matrix A and B. The resulting matrix is C.*

Table XIII: *Shortages' evaluation*

Required widths	***Required number of reels***	***Matrix C***	***Shortages***	***Excess***
5	50	48	2	0
6	70	69	1	0

Table XIV: *Shortages' values in required widths*

Required Widths	X_1	X_4	***Shortages***
5	0	4	2
6	3	0	1

Minimize: $Z = X_1 + X_4$

Subject to:

$$4X_4 \geq 2$$
$$3X_1 \geq 1$$

Solving by MATLAB predefined binary programming tool for binary answers of the variables X_1 and X_4.

$$X_4 = 1$$
$$X_1 = 1$$

Table XV: *Final optimal solution*

	Optimal solution of the variables in Phase-I	***Binary values of the variables in Phase-II***	***Adding***	***Final Optimal Solution***
X_1	23	1	23+1	24
X_4	12	1	12+1	12

The overall final optimal solution is:

$X_1 = 24$

$X_4 = 13$

The final optimal solution calls for cutting 24 master reels of width 20 according to setting X_1 and 13 master reels of width 20 according to setting X_4.

Total area of the selected patterns = [(24×20) + (13×20) + 0] ×L
The zero (0) written in the above equation denotes that no pattern is selected of the stocked reels.
Total area of the selected patters = 740×L
Total area of reels demanded = [(5×50) + (6×70)] ×L
Total area of reels demanded = 670×L
Total useful area of reels produced for this order = [(24×18) + (13×20)] ×L
Total useful area of reels produced for this order = 692×L
Area of reels stocked after marketing the order = Total useful area of reels produced for this order - Total area of order
Area of reels stocked after marketing the order = 692×L - 670×L
Area of reels stocked after marketing the orders = 22×L
Trim Loss = Total area of the selected patters - Total useful area of reels produced for this order
Trim Loss = (740×L) - (692×L)
Trim Loss = 48×L

VII. CONCLUSION

This study introduces a two step approach to solving cutting stock problem. The first phase is essentially the Simplex Method. The second phase is required only if the solution obtained is non-integer. The method has been employed successfully on a number of cutting stock problems and optimal solutions obtained in small number of iterations.

It is shown and described that the automated planning of cutting master reels and reels present at stock has important advantages and benefits for industrial purposes. The production cycle, office work and calculations of managers, utilities and labor work can be reduced and time can be optimized allowing better customer service and satisfaction. This system and procedure developed is now being used at Sarhad Board and Paper Mill, Peshawar and the results obtained have been quite satisfactory as are considerably economical and optimized.

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