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THE TRIM - LOSSREDUCTIONPROBLEM IN INDUSTRY

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CHAPTER - I

I - 1 Introduction

The process of finding a best way is called , "optimisation." Most industrial projects involve the optimization of a system, such as minimizing production costs, or minimizing the cost of achieving certain technical properties for some engineering entity or operation. On the other hand, optimization may be maximizing profits or capacity of a flow of goods or informations through a network, ...etc.

One of the most applicable industrial projects, and of primary significance to a variety of industries is the so-named "Trim Loss" or "Cutting stock" problem. This problem is concerned with cutting rolls of paper, textiles, metallic foils, cellophane, or other materials into a desired number of subparts such that the amount of "waste" is minimized.*

Nowadays, large general purpose computers used to solve problems of many factories , businesses , universities, ...etc.

In our research, after formulating the problem, we will expose the different approaches and techniques to solve it. Finally, a description for a personal computer program designed and written in order to put the problem in an executable way. The research could be applied in paper mill industries as well as in metallic and textile socities of small or large scales.

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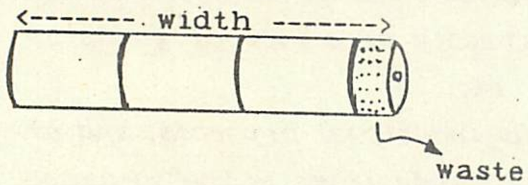
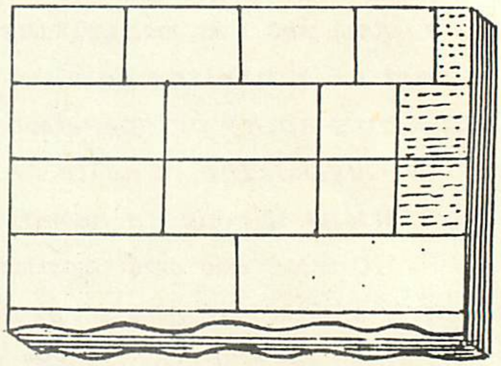
* Waste is defined in our problem, as any left over portions of a jumbo reel which cannot be used to meet demand.

I - 2 Technique of cutting process

In textile, metallic, wooden and paper mill industries, the raw material take the form of rolls or jumbo reels or slices of certain width, (fig. 1).





(fig. 1)

The company receives orders to cut, some of these reels or slices, to a set of sub reels of various width, suitable for the manufacturing necessities or the customer's demands. A number of cutting machines are at the disposal of the company, and their knives can be set for any combination of widths in which the total combined does not exceedthe overall roll width.

In fitting the list of orders to the available rolls and machines, it is generally found that trimming losses are unavoidable ; this wasted material represents a total loss, which may be somewhat alleviated by selling it as scrap. The firm wishes to determine how to meet these orders so as to minimize total waste.

As a start, the firm has to determine the different patterns which can be used in slitting a jumbo reel, and note the attendant loss. It will only consider patterns which yield waste less than the smallest required width.

I - 3 Formulation of the problem

Before formulating the problem, suppose the following example .

Example :

A paper mill produces paper in reels of standard width 60 inches, the required minimum number of rolls or slices for each width ,the have been received as follows :

Width in inches	28	20	15
Length ordered	30	60	48

To begin with, we determine the following possible partitions of 60 inches in to the required width ..

Width \ Combination	1	2	3	4	5	6	7	Minimum no of rolls..
28	2	1	1	0	0	0	0	30
20	0	1	0	3	2	1	0	60
15	0	0	2	0	1	2	4	48
T R I M	4	12	2	0	5	10	0	

The requirement for a length of 30 and width 28 will be satisfied if :

$$2 X1 + X2 + X3 \geq 30$$

where Xi, denote the length of standard reel that will be processed according to combination i .

Also for the other lengths and widths :

$$X2 + 3 X4 + 2 X5 + X6 \geq 60$$

$$2 X3 + X5 2 X6 + 4 X7 \geq 48$$

The total trim loss to be minimized is ,

$$4 X1 + 12 X2 + 2 X3 + 5 X5 + 10 X6 + 28 X8 + 20 X9 + 15 X10 \qquad (1)$$

where X8 , X9 and X10 are slack variables .

However, it is simpler to look at the problem from another point of view. The lengths of the reels for the various combinations are X1, X2, ..., X7 and therefore the total area actually cut will be 60 * (X1 +X2 + ... +X7).

The total area of the paper ordered is :

$$28 * 30 + 20 * 60 + 15 * 48 .$$

The difference between the two is the trim, and the latter will be minimized if :

$$X1 + X2 + ... + X7 \text{ is minimized.}$$

Equation (1) with the above constraints represent a linear programming problem which could be easily solved to obtain :

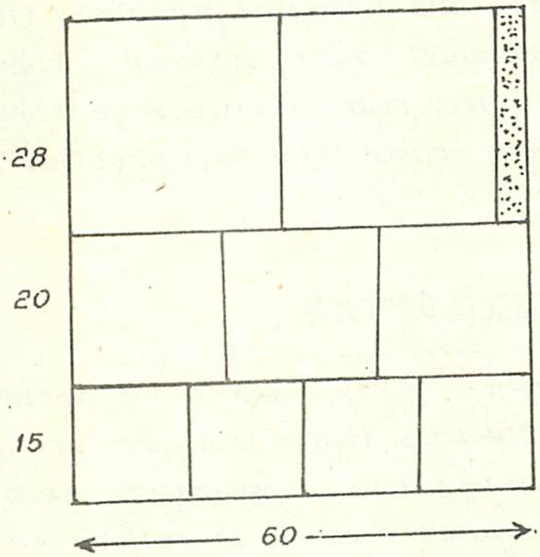
$$X1 = X4 = X7 = 1 \text{ and}$$

$$X2 = X3 = X5 = X6 = 0.$$

This means, that the combinations which will give minimum trim loss are :

Combination number 1 :	2 x 28
Combination number 4 :	3 x 20
Combination number 7 :	4 x 15

Since the ordered length of width 28 inches is 30, then we should have to cut 30 / 2 = 15 large rolls. Similarly, we should have to cut 60 / 3 = 20 large rolls to satisfy the ordered length with combination number 4, and to cut 48 / 4 = 12 large rolls for the last ordered length, with a total loss trim equal to 60 .



(fig.2)

It could be happened that, there are more than one optimal solution (multiple solutions). For example :

2 * 28 & 3 * 20 & 4 * 15 gives the same total loss trim.

So, the problem could be stated as :

Given quantities of goods (rolls or slices) of different shapes to be cut from a material that comes in various sizes, a number of possible efficient patterns are considered. How much of each pattern should be cut ? The number of each pattern cut represent the decision variables. The constraints are given by the required quantities and by the amount of material of each size available. The objective may be to minimize the cost of the material used or the amount of waste produced.

I - 4 Some coherent problems

Although, our problem "the trim loss " was tackled in some other references under the name of " Cutting stock problem*" but, there are a host of problems that fit this structure, some are seemingly quite different . These problems could be treated and solved nearly by the same technique, after adding or deleting some constraints .Such problems like the so-called :

I - 4 - a: The knapsack problem

It is also known as " Fly - away - kit problem**", or / and loading problem. The basic idea is that there are N different types of items that can be put in to a knapsack. Each item has a certain weight associated with it, as well as a value. The problem is to determine how many units of each item to place in the knapsack in order to maximize the total value. The problem could be formulated as follow :

(*) " Principles of operations research for management" Budnick, Mojena, Vollmann - 1977 IRWIN.

(**) " Introduction to operations research techniques" H.G.Dacllenbach & J.A.George & D.C.Mc Nickle-1983 ALLYN&BACON

$$\text{Maximize } Z = \sum_{i=1}^{N} X_i \cdot V_i .$$

subject to :

$$\sum_{i=1}^{N} X_i \cdot w_i \leq W .$$

$$X_i = \begin{cases} 0 \\ 1 \end{cases} \quad \text{for } i = 1,2,\ldots, N ;$$

where V_i , w_i are the value and weight of item i .

I - 4 - b: The allocation problem :

This type of problems is interest in covering an area of vital concern - as possible as we can by a limited personnel (fire fighters, police, ambulance drivers, ... etc.), supported by a suitable equipment (fire trucks, patrol cars, ambulances or rescue trucks, ... etc.).

The problem is to deploy these resources in order to achieve as close as possible the objectives of the emergency response function. The problem could be formulated as follow :
For any vertex i, only the set N_i of vertices within T (maximum response time) of i can provide an acceptable emergency service to i;

$N_i = \{ j;\ d_{ji} \leq T ,\ i \in X$ and j is a possible node for a facility location $\}$.

The decision variables x_j are defined as :

$$x_j = \begin{cases} 0 \text{ if no facility is established at vertex } j. \\ 1 \text{ if a facility is established at vertex } j \text{ for all possible facility location vertices } j . \end{cases}$$

Also :

$$\sum_{j \in N_i} x_j \geq 1 \text{ for } i = 1,2, \ldots ,n.$$

(n : number of vertices which have to be served);
and the objective Z is to minimize the total number of facility locations used, i.e :

$$\min : Z = \sum_{j=1}^{m} x_j$$

(m : the total number of possible facility locations).

Chapter - II

Some obstacles in solving the trim loss problem :

To put the problem in a practical use and application, we have to overcome two major problems :

II - 1 : Fractional solutions

It is clear from the formulation of the problem that, the trim problem is one in which the decision variables x_i must be integers . In applying linear programming techniques, we cannot guarantee an integer optimal solution. Also, the approach of rounding the linear programming solution to the nearest integer solution is not a good strategy. For example, the following linear programming problem :

$$\text{Max } 2\,x_1 + 3\,x_2$$

such that

$$130\,x_1 + 182\,x_2 \leq 910\,,$$
$$4\,x_1 + 40\,x_2 \leq 140\,,$$
$$x_1 \leq 4$$
$$\text{and } x_1\,,\,x_2 \geq 0\,;$$

has an optimal solution at $x_1 = 2.44$ & $x_2 = 3.26$.

If this solution is rounded to :

$$x_1 = 2 \text{ and } x_2 = 3\,,$$

the objective function will have the value of 13 ; whereas the optimal integer solution is at : $x_1 = 4$ and $x_2 = 2$, with an objective function equal to 14 . For this reason, it is essential to put the linear integer programming techniques in to consideration, to solve this kind of problems .

Unfortunately, there is no single method, such as the simplex method - in linear programming problems - that has been accepted as the "only" method for solving all types of integer linear programming models . However, all of the known methods in integer linear programming are primarily based on one of the following four approaches :

i) Some type of enumeration. ii) Cutting plane .

iii) Bender's decomposition. vi) Group theory .

We will apply in this research two computer programs for the first two approaches, if the linear programming technique fails in giving us the desired integer solution .

II - 2 : Generating the cutting patterns

Each setting of the cutting blades yields a set of smaller rolls, and the problem then becomes the determination of how the blades should be positioned and, for a given setting of the blades, how many large rolls should be cut. Thus, the first thing to be done is to determine which setting of the blades yields rolls that can be used. Each distinct setting is a variable of the problem and the value of each variable represents how many rolls of standard width should be cut at the corresponding setting of the blades.

Returning to the table of the different combinations in (I - 3). After arranging the required widths in descending order, we notice that, for every combination there is a cutting - pattern vector :

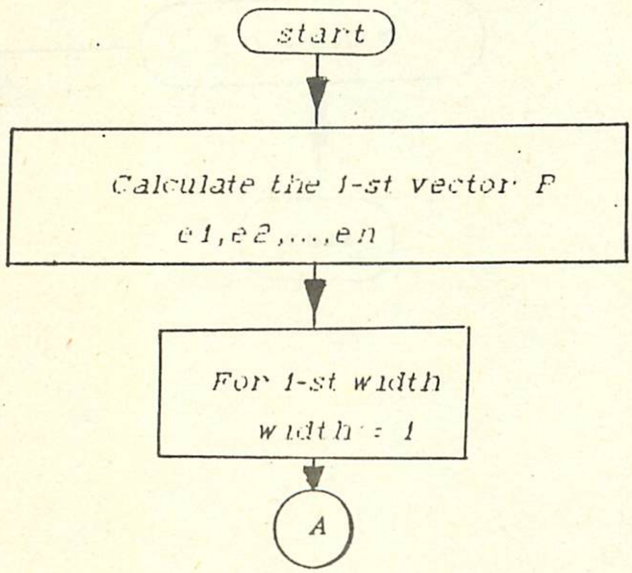
$$p = \begin{bmatrix} e1 \\ e2 \\ e3 \end{bmatrix}$$ satisfies the condition :

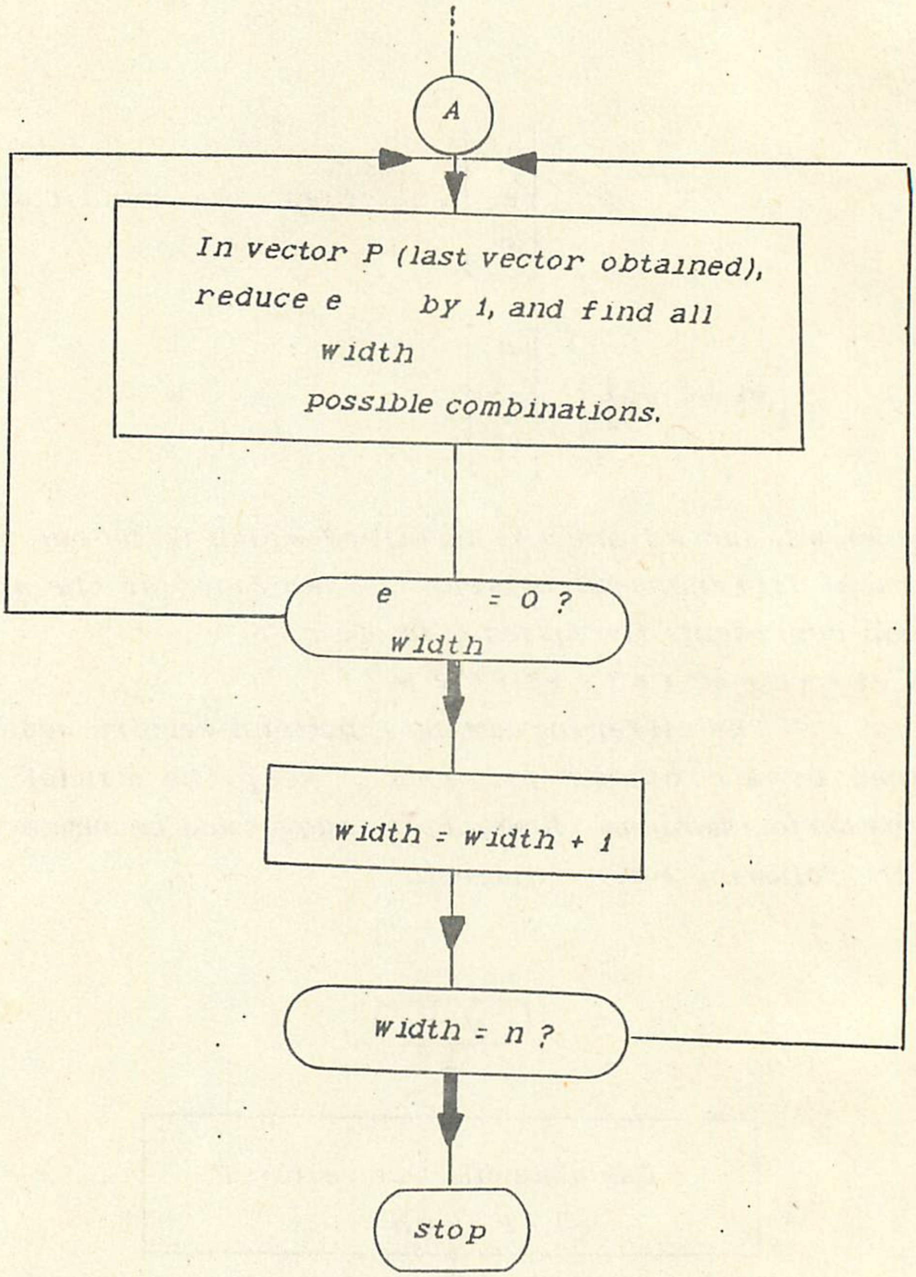
$$\begin{bmatrix} w1 & w2 & w3 \end{bmatrix} \begin{bmatrix} e1 \\ e2 \\ e3 \end{bmatrix} \leq W$$

where w1, w2, and w3 are the required width to be cut. The numerical difference C between the two sides of the above equation represents the lossed trim, i.e ;

$$w1 * e1 + w2 * e2 + w3 * e3 + C = W$$

The different cutting - pattern vectors could be obtained by a computer program to keep the manual data preparation to a minimum. However, the steps could be summarized as in the following block - diagram.




A
In vector P (last vector obtained), reduce e by 1, and find all
width
possible combinations.
e = 0 ?
width
width = width + 1
width = n ?
stop

Chapter - III

Algorithm and results

Since the problem could be solved by a method or more, and not by some other methods; so the algorithm which we applied in writing the program consist of five major parts :-

1 - The input data

In running the program, the computer will print the following messages :

a) PLEASE ENTER NUMBER OF REQUIRED WIDTHS.

i.e; the __number__ of different cutting orders. In our example of (I - 3), there are 3 different widths in inches. So, we have to type 3 and press RETURN key .

b) PLEASE ENTER STANDARD WIDTH OF ROLLS

It is clear, that the reels or slices have a standard width. It is 60 inches in our example. So, type 60 and press RETURN key.

c) In the 3-rd section of input data, the computer will ask about each required width wi, and the required number of rolls or slices for that width.

2 - Generating the cutting patterns

As described in (II- 2), a subroutine sub - program is written to give all the possible combinations of the cutting patterns. For each combination, the program calculates the corresponding trim, the value which will be a member in the minimized objective function.

3 - Constructing the objective function and all constraints

The subroutine sub-program of the second part, will provide us with 2 major data values:

i) the trim for each combination which constitute the coefficients of the basic variables in the objective function;

ii) in every combination, an integer number for every width, representing the number of parts to be cut from every roll or slice. These integer numbers in front of each width represent the coefficients of the basic variables in one constraint. Its right-hand side is the required minimum number of rolls or slices; see (fig.2) in the example presented in (I - 3). The program construct automatically - with the output of the 2.nd part, the objective function and all the constraints of the model (linear or integer linear programming).

4 - Solving the model

As we mentioned in the previous part, that it could be found two models to be applied in order to obtain the final results; linear or integer linear programming model. Since the constraints in the linear programming model are of the type (>/); the simplex two - phase method was applied to solve the problem. The program will examine the case of "multiple solutions", and displays it, if exists. If this model fails to give integer values for the basic variables, one of two integer linear programming models or both, could be applied to the problem. The two other models are enumeration and cutting plane methods.

5 - Calculating the total lossed trim

Reaching the optimal solution for the problem, the computer displays the cutting procedure under the following title:

" THE FEASIBLE SOLUTION IS "

The different cutting patterns, choosed by the program and which give the optimal solution will be displayed as :

WE SHOULD CUT [xxx] LARGE ROLLS USING THE BLADE POSITION OF

COMBINATION NUMBER [?]

CUT [A] ROLLS OF WIDTH ..... [X] INCH.

CUT [B] ROLLS OF WIDTH ..... [Y] INCH.

CUT [C] ROLLS OF WIDTH ..... [Z] INCH.

....

After displaying the way of cutting in each combination, the program displays the following message :

IF THE LOSSED TRIM EQUAL TO ZERO THEN TOTAL AREA = VVVV INCH

where VVVV = number of large rolls of x standard width.

Also, the program will calculate the total net area (TNA), to be cut from the large rolls, i.e.

$$TNA = \sum_{i=1}^{\text{no. of combinations}} (Ai.xi.xxxi + Bi.Yi.xxxi + Ci.Zi.xxxi).$$

To display the value of TNA, the program will give the message :

TOTAL NET AREA TO BE CUT = ???? INCH .

The difference between the two previous values gives the total lossed trim. This difference will appear under the title :

TOTAL LOSSED TRIM = ???? INCH

RESULTS

using

INTEGER LINEARPROGRAMMING

INTEGER LINEAR PROG.

THE GIVEN DATA IS.

STANDARD WIDTH = 20 INCH
WE REQUIRED [300] ROLL(S) OF WIDTH ..... [9] INCH
WE REQUIRED [200] ROLL(S) OF WIDTH ..... [7] INCH
WE REQUIRED [150] ROLL(S) OF WIDTH ..... [5] INCH

===

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6
9	2	1	1	0	0	0
7	0	1	0	2	1	0
5	0	0	2	1	2	4
TRIM	2	4	1	1	3	0

===

THE FEASIBLE SOLUTION IS

WE SHOULD CUT [150] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [2] ROLLS OF WIDTH ..... [9] INCH
CUT [0] ROLLS OF WIDTH ..... [7] INCH
CUT [0] ROLLS OF WIDTH ..... [5] INCH

WE SHOULD CUT [100] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [4]

CUT [0] ROLLS OF WIDTH ..... [9] INCH
CUT [2] ROLLS OF WIDTH ..... [7] INCH
CUT [1] ROLLS OF WIDTH ..... [5] INCH

WE SHOULD CUT [13] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [6]

CUT [0] ROLLS OF WIDTH ..... [9] INCH
CUT [0] ROLLS OF WIDTH ..... [7] INCH
CUT [4] ROLLS OF WIDTH ..... [5] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 5250 INCH

TOTAL NET AREA TO BE CUT = 4850 INCH

TOTAL LOSSED TRIM =-400 INCH

==

CALCULATION TIME = 00:01:07

THERE ARE MULTIPLE SOLUTIONS
THE FEASIBLE SOLUTION IS

WE SHOULD CUT [138] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [2] ROLLS OF WIDTH ..... [9] INCH
CUT [0] ROLLS OF WIDTH ..... [7] INCH
CUT [0] ROLLS OF WIDTH ..... [5] INCH

WE SHOULD CUT [100] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [4]

CUT [0] ROLLS OF WIDTH ..... [9] INCH
CUT [2] ROLLS OF WIDTH ..... [7] INCH
CUT [1] ROLLS OF WIDTH ..... [5] INCH

WE SHOULD CUT [25] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [3]

CUT [1] ROLLS OF WIDTH ..... [9] INCH
CUT [0] ROLLS OF WIDTH ..... [7] INCH
CUT [2] ROLLS OF WIDTH ..... [5] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 5250 INCH

TOTAL NET AREA TO BE CUT = 4850 INCH

TOTAL LOSSED TRIM =-400 INCH
==
CALCULATION TIME = 00:01:46

INTEGER LINEAR PROG.

THE GIVEN DATA IS

STANDARD WIDTH = 40 INCH
WE REQUIRED [60] ROLL(S) OF WIDTH ..... [12] INCH
WE REQUIRED [30] ROLL(S) OF WIDTH ..... [10] INCH
WE REQUIRED [50] ROLL(S) OF WIDTH ..... [7] INCH

==

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6	7	8	9	10	11
12	3	2	2	1	1	0	0	0	0	0	1
10	0	1	0	2	0	4	3	2	1	0	2
7	0	0	2	1	4	0	1	2	4	5	1
TRIM	4	6	2	1	0	0	3	6	2	5	1

==

THE FEASIBLE SOLUTION IS

WE SHOULD CUT [190] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

WE SHOULD CUT [8] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [6]

CUT [0] ROLLS OF WIDTH ..... [12] INCH
CUT [4] ROLLS OF WIDTH ..... [10] INCH
CUT [0] ROLLS OF WIDTH ..... [7] INCH

WE SHOULD CUT [60] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [5]

CUT [1] ROLLS OF WIDTH ..... [12] INCH
CUT [0] ROLLS OF WIDTH ..... [10] INCH
CUT [4] ROLLS OF WIDTH ..... [7] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 2700 INCH

TOTAL NET AREA TO BE CUT = 2700 INCH

TOTAL LOSSED TRIM =-3.814697E-06 INCH

==

CALCULATION TIME = 00:01:08

INTEGER LINEAR PROG.

THE GIVEN DATA IS

STANDARD WIDTH = 60 INCH
WE REQUIRED [30] ROLL(S) OF WIDTH ..... [28] INCH
WE REQUIRED [60] ROLL(S) OF WIDTH ..... [20] INCH
WE REQUIRED [40] ROLL(S) OF WIDTH ..... [15] INCH

==

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6	7
28	2	1	1	0	0	0	0
20	0	1	0	3	2	1	0
15	0	0	2	0	1	2	4
TRIM	4	12	2	0	5	10	0

THE FEASIBLE SOLUTION IS

WE SHOULD CUT [15] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [2] ROLLS OF WIDTH ..... [28] INCH
CUT [0] ROLLS OF WIDTH ..... [20] INCH
CUT [0] ROLLS OF WIDTH ..... [15] INCH

WE SHOULD CUT [20] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [4]

CUT [0] ROLLS OF WIDTH ..... [28] INCH
CUT [3] ROLLS OF WIDTH ..... [20] INCH
CUT [0] ROLLS OF WIDTH ..... [15] INCH

WE SHOULD CUT [12] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [7]

CUT [0] ROLLS OF WIDTH ..... [28] INCH
CUT [0] ROLLS OF WIDTH ..... [20] INCH
CUT [4] ROLLS OF WIDTH ..... [15] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 2820 INCH

TOTAL NET AREA TO BE CUT = 2760 INCH

TOTAL LOSSED TRIM =-60 INCH

==

CALCULATION TIME = 00:01:05

INTEGER LINEAR PROG.

THE GIVEN DATA IS

STANDARD WIDTH = 80 INCH
WE REQUIRED [100] ROLL(S) OF WIDTH ..... [35] INCH
WE REQUIRED [130] ROLL(S) OF WIDTH ..... [20] INCH
WE REQUIRED [80] ROLL(S) OF WIDTH ..... [15] INCH
WE REQUIRED [80] ROLL(S) OF WIDTH ..... [10] INCH

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
35	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
20	0	2	0	0	4	3	3	2	2	1	1	0	0	0	0	0	0	1
15	0	0	3	0	0	1	0	2	0	4	0	5	4	3	2	1	0	1
10	1	0	0	4	0	0	2	1	4	0	6	0	2	3	5	6	8	1
TRIM	0	5	0	5	0	5	0	0	0	0	0	5	0	5	0	5	0	0

INTEGER LINEAR PROG.

THE GIVEN DATA IS

STANDARD WIDTH = 90 INCH
WE REQUIRED [30] ROLL(S) OF WIDTH ..... [15] INCH
WE REQUIRED [20] ROLL(S) OF WIDTH ..... [12] INCH
WE REQUIRED [50] ROLL(S) OF WIDTH ..... [8] INCH

==

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
15	6	5	5	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0	0	4
12	0	1	0	2	0	3	0	5	0	6	0	7	6	5	4	3	2	1	0	1
8	0	0	1	0	3	1	5	0	7	0	9	0	2	3	5	6	8	9	11	2
TRIM	0	3	7	6	6	1	5	0	4	3	3	6	2	6	2	6	2	6	2	2

==

THE FEASIBLE SOLUTION IS

WE SHOULD CUT [4] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [6] ROLLS OF WIDTH ..... [15] INCH
CUT [0] ROLLS OF WIDTH ..... [12] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [4] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [8]

CUT [2] ROLLS OF WIDTH ..... [15] INCH
CUT [5] ROLLS OF WIDTH ..... [12] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [5] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [19]

CUT [0] ROLLS OF WIDTH ..... [15] INCH
CUT [0] ROLLS OF WIDTH ..... [12] INCH
CUT [11] ROLLS OF WIDTH ..... [8] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 1099.091 INCH

TOTAL NET AREA TO BE CUT = 1090 INCH

TOTAL LOSSED TRIM =-9.090909 INCH
==
CALCULATION TIME = 00:01:24

THE GIVEN DATA IS

STANDARD WIDTH = 100 INCH
WE REQUIRED [50] ROLL(S) OF WIDTH ..... [50] INCH
WE REQUIRED [120] ROLL(S) OF WIDTH ..... [25] INCH
WE REQUIRED [10] ROLL(S) OF WIDTH ..... [22] INCH
WE REQUIRED [40] ROLL(S) OF WIDTH ..... [8] INCH

==

THIS IS ALL COMBINATIONS

WID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
50	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
25	0	2	0	0	4	3	3	2	2	1	1	0	0	0	0	0
22	0	0	2	0	0	1	0	2	0	3	0	4	3	2	1	0
8	0	0	0	6	0	0	3	0	6	1	9	1	4	7	9	12
TRIM	0	0	6	2	0	3	1	6	2	1	3	4	2	0	6	4

THE FEASIBLE SOLUTION IS

WE SHOULD CUT [25] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [2] ROLLS OF WIDTH ..... [50] INCH
CUT [0] ROLLS OF WIDTH ..... [25] INCH
CUT [0] ROLLS OF WIDTH ..... [22] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [30] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [5]

CUT [0] ROLLS OF WIDTH ..... [50] INCH
CUT [4] ROLLS OF WIDTH ..... [25] INCH
CUT [0] ROLLS OF WIDTH ..... [22] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [6] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [14]

CUT [0] ROLLS OF WIDTH ..... [50] INCH
CUT [0] ROLLS OF WIDTH ..... [25] INCH
CUT [2] ROLLS OF WIDTH ..... [22] INCH
CUT [7] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [1] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 6071.429 INCH

TOTAL NET AREA TO BE CUT = 6071.429 INCH

TOTAL LOSSED TRIM =-2.384186E-07 INCH

==

CALCULATION TIME = 00:01:43

THERE ARE MULTIPLE SOLUTIONS
THE FEASIBLE SOLUTION IS

WE SHOULD CUT [50] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [2]

CUT [1] ROLLS OF WIDTH ..... [50] INCH
CUT [2] ROLLS OF WIDTH ..... [25] INCH
CUT [0] ROLLS OF WIDTH ..... [22] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [5] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [5]

CUT [0] ROLLS OF WIDTH ..... [50] INCH
CUT [4] ROLLS OF WIDTH ..... [25] INCH
CUT [0] ROLLS OF WIDTH ..... [22] INCH
CUT [0] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [6] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [14]

CUT [0] ROLLS OF WIDTH ..... [50] INCH
CUT [0] ROLLS OF WIDTH ..... [25] INCH
CUT [2] ROLLS OF WIDTH ..... [22] INCH
CUT [7] ROLLS OF WIDTH ..... [8] INCH

WE SHOULD CUT [1] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION.

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 6071.429 INCH

TOTAL NET AREA TO BE CUT = 6071.429 INCH

TOTAL LOSSED TRIM =-2.384186E-07 INCH

==

CALCULATION TIME = 00:02:40

RESULTS
===========

using

L I N E A R PROGRAMMING

LINEAR PROGRAMMING

STANDARD WIDTH = 20 INCH

WE REQUIRED [300] ROLLS OF WIDTH ... [9] INCH

WE REQUIRED [200] ROLLS OF WIDTH ... [7] INCH

WE REQUIRED [150] ROLLS OF WIDTH ... [5] INCH

THE PROBLEM IS TO MINIMIZE :

2 X 1 + 4 X 2 + 1 X 3 + 1 X 4 + 3 X 5 + 0 X 6 + 9 X 7 + 7 X 8 +
5 X 9

S.T. :

2 X 1 +1 X 2 +1 X 3 +0 X 4 +0 X 5 +0 X 6 +0 X 7 +0 X 8 +
0 X 9 >/ 300

0 X 1 +1 X 2 +0 X 3 +2 X 4 +1 X 5 +0 X 6 +0 X 7 +0 X 8 +
0 X 9 >/ 200

0 X 1 +0 X 2 +2 X 3 +1 X 4 +2 X 5 +4 X 6 +0 X 7 +0 X 8 +
0 X 9 >/ 150

!!!!!!!!!!!!!!!!

BASIC SOLUTION 1
XB(1) = X(13) = 300
XB(2) = X(14) = 200
XB(3) = X(15) = 150
CURRENT VALUE OF THE OBJ. FUNC. IS -650000

BASIC SOLUTION 2
XB(1) = X(13) = 300
XB(2) = X(14) = 200
XB(3) = X(6) = 37.5
CURRENT VALUE OF THE OBJ. FUNC. IS -500000

BASIC SOLUTION 3
XB(1) = X(13) = 300
XB(2) = X(4) = 100
XB(3) = X(6) = 12.5
CURRENT VALUE OF THE OBJ. FUNC. IS -300100

BASIC SOLUTION 4
XB(1) = X(1) = 150
XB(2) = X(4) = 100
XB(3) = X(6) = 12.5
CURRENT VALUE OF THE OBJ. FUNC. IS -400

THE LAST BASIC FEASIBLE SOLUT. IS OPTIMAL

THE OPTIMAL VALUE OF THE OBJ. FUN. IS 400

TOTAL LOSSED TRIM = 400 INCH

WE SHOULD CUT :

[150] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 1

[100] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 4

[12.5] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 6

CALCULATION TIME = 00:00:32

```
STANDARD WIDTH = 40  INCH
WE REQUIRED [ 60 ] ROLLS OF WIDTH ... [ 12 ] INCH
WE REQUIRED [ 30 ] ROLLS OF WIDTH ... [ 10 ] INCH
WE REQUIRED [ 50 ] ROLLS OF WIDTH ... [ 7 ] INCH


THE PROBLEM IS TO MINIMIZE :
4 X 1 + 6 X 2 + 2 X 3 + 1 X 4 + 0 X 5 + 0 X 6 + 3 X 7 + 6 X 8 +
2 X 9 + 5 X 10 + 1 X 11 + 12 X 12 + 10 X 13 + 7 X 14

S.T. :
3 X 1 +2 X 2 +2 X 3 +1 X 4 +1 X 5 +0 X 6 +0 X 7 +0 X 8 +
0 X 9 +0 X 10 +1 X 11 +0 X 12 +0 X 13 +0 X 14     >/ 60

0 X 1 +1 X 2 +0 X 3 +2 X 4 +0 X 5 +4 X 6 +3 X 7 +2 X 8 +
1 X 9 +0 X 10 +2 X 11 +0 X 12 +0 X 13 +0 X 14     >/ 30

0 X 1 +0 X 2 +2 X 3 +1 X 4 +4 X 5 +0 X 6 +1 X 7 +2 X 8 +
4 X 9 +5 X 10 +1 X 11 +0 X 12 +0 X 13 +0 X 14     >/ 50


    $$$$$$$$$$$$$$$
  BASIC SOLUTION  1
  XB( 1 ) = X( 18 ) =  60
  XB( 2 ) = X( 19 ) =  30
  XB( 3 ) = X( 20 ) =  50
CURRENT VALUE OF THE OBJ. FUNC. IS -140000
  BASIC SOLUTION  2
  XB( 1 ) = X( 18 ) =  47.5
  XB( 2 ) = X( 19 ) =  30
  XB( 3 ) = X( 5 ) =  12.5
CURRENT VALUE OF THE OBJ. FUNC. IS -77500
  BASIC SOLUTION  3
  XB( 1 ) = X( 18 ) =  47.5
  XB( 2 ) = X( 6 ) =  7.5
  XB( 3 ) = X( 5 ) =  12.5
CURRENT VALUE OF THE OBJ. FUNC. IS -47500
  BASIC SOLUTION  4
  XB( 1 ) = X( 1 ) =  15.83333
  XB( 2 ) = X( 6 ) =  7.5
  XB( 3 ) = X( 5 ) =  12.5
CURRENT VALUE OF THE OBJ. FUNC. IS -63.33333
  BASIC SOLUTION  5
  XB( 1 ) = X( 17 ) =  190
  XB( 2 ) = X( 6 ) =  7.5
  XB( 3 ) = X( 5 ) =  60
CURRENT VALUE OF THE OBJ. FUNC. IS  0
THE LAST BASIC FEASIBLE SOLUT. IS OPTIMAL
THE OPTIMAL VALUE OF THE OBJ. FUN. IS 0
  TOTAL LOSSED TRIM = 0  INCH
```

WE SHOULD CUT :
========================

[190] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 17

[7.5] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 6

[60] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 5

CALCULATION TIME = 00:00:38

LINEAR PROGRAMMING

STANDARD WIDTH = 60 INCH
WE REQUIRED [30] ROLLS OF WIDTH ... [28] INCH
WE REQUIRED [60] ROLLS OF WIDTH ... [20] INCH
WE REQUIRED [48] ROLLS OF WIDTH ... [15] INCH

THE PROBLEM IS TO MINIMIZE :
4 X 1 + 12 X 2 + 2 X 3 + 0 X 4 + 5 X 5 + 10 X 6 + 0 X 7 + 28 X 8 + 20 X 9 + 15 X 10

S.T. :
2 X 1 + 1 X 2 + 1 X 3 + 0 X 4 + 0 X 5 + 0 X 6 + 0 X 7 + 0 X 8 + 0 X 9 + 0 X 10 >/ 30

0 X 1 + 1 X 2 + 0 X 3 + 3 X 4 + 2 X 5 + 1 X 6 + 0 X 7 + 0 X 8 + 0 X 9 + 0 X 10 >/ 60

0 X 1 + 0 X 2 + 2 X 3 + 0 X 4 + 1 X 5 + 2 X 6 + 4 X 7 + 0 X 8 + 0 X 9 + 0 X 10 >/ 48

****

BASIC SOLUTION 1
XB(1) = X(14) = 30
XB(2) = X(15) = 60
XB(3) = X(16) = 48
CURRENT VALUE OF THE OBJ. FUNC. IS -138000
BASIC SOLUTION 2
XB(1) = X(14) = 30
XB(2) = X(15) = 60
XB(3) = X(7) = 12
CURRENT VALUE OF THE OBJ. FUNC. IS -90000
BASIC SOLUTION 3
XB(1) = X(14) = 30
XB(2) = X(4) = 20
XB(3) = X(7) = 12
CURRENT VALUE OF THE OBJ. FUNC. IS -30000
BASIC SOLUTION 4
XB(1) = X(1) = 15
XB(2) = X(4) = 20
XB(3) = X(7) = 12
CURRENT VALUE OF THE OBJ. FUNC. IS -60
THE LAST BASIC FEASIBLE SOLUT. IS OPTIMAL
THE OPTIMAL VALUE OF THE OBJ. FUN. IS 60
TOTAL LOSSED TRIM = 60 INCH

WE SHOULD CUT :
========================

[15] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 1

[20] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 4

[12] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 7

CALCULATION TIME = 00:00:32

THERE ARE MULTIPLE SOLUTIONS
THE FEASIBLE SOLUTION IS

WE SHOULD CUT [3] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [1]

CUT [2] ROLLS OF WIDTH ..... [28] INCH
CUT [0] ROLLS OF WIDTH ..... [20] INCH
CUT [0] ROLLS OF WIDTH ..... [15] INCH

WE SHOULD CUT [20] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [4]

CUT [0] ROLLS OF WIDTH ..... [28] INCH
CUT [3] ROLLS OF WIDTH ..... [20] INCH
CUT [0] ROLLS OF WIDTH ..... [15] INCH

WE SHOULD CUT [24] LARGE ROLLS USING THE BLADE POSITION OF COMBINATION

NUMBER [3]

CUT [1] ROLLS OF WIDTH ..... [28] INCH
CUT [0] ROLLS OF WIDTH ..... [20] INCH
CUT [2] ROLLS OF WIDTH ..... [15] INCH

IF THE LOSSED TRIM IS EQUAL TO ZERO THEN TOTAL AREA = 2820 INCH

TOTAL NET AREA TO BE CUT = 2760 INCH

TOTAL LOSSED TRIM =-60 INCH
==
CALCULATION TIME = 00:01:55

LINEAR PROGRAMMING

STANDARD WIDTH = 80 INCH
WE REQUIRED [100] ROLLS OF WIDTH ... [35] INCH
WE REQUIRED [130] ROLLS OF WIDTH ... [20] INCH
WE REQUIRED [80] ROLLS OF WIDTH ... [15] INCH
WE REQUIRED [80] ROLLS OF WIDTH ... [10] INCH

THE PROBLEM IS TO MINIMIZE :

0 X 1 + 5 X 2 + 0 X 3 + 5 X 4 + 0 X 5 + 5 X 6 + 0 X 7 + 0 X 8 +
0 X 9 + 0 X 10 + 0 X 11 + 5 X 12 + 0 X 13 + 5 X 14 + 0 X 15 + 5
X 16 + 0 X 17 + 0 X 18 + 35 X 19 + 20 X 20 + 15 X 21 + 10 X 22

S.T. :

2 X 1 + 1 X 2 + 1 X 3 + 1 X 4 + 0 X 5 + 0 X 6 + 0 X 7 + 0 X 8 +
0 X 9 + 0 X 10 + 0 X 11 + 0 X 12 + 0 X 13 + 0 X 14 + 0 X 15 + 0
X 16 + 0 X 17 + 1 X 18 + 0 X 19 + 0 X 20 + 0 X 21 + 0 X 22
>/ 100

0 X 1 + 2 X 2 + 0 X 3 + 0 X 4 + 4 X 5 + 3 X 6 + 3 X 7 + 2 X 8 +
2 X 9 + 1 X 10 + 1 X 11 + 0 X 12 + 0 X 13 + 0 X 14 + 0 X 15 + 0
X 16 + 0 X 17 + 1 X 18 + 0 X 19 + 0 X 20 + 0 X 21 + 0 X 22
>/ 130

0 X 1 + 0 X 2 + 3 X 3 + 0 X 4 + 0 X 5 + 1 X 6 + 0 X 7 + 2 X 8 +
0 X 9 + 4 X 10 + 0 X 11 + 5 X 12 + 4 X 13 + 3 X 14 + 2 X 15 + 1
X 16 + 0 X 17 + 1 X 18 + 0 X 19 + 0 X 20 + 0 X 21 + 0 X 22
>/ 80

1 X 1 + 0 X 2 + 0 X 3 + 4 X 4 + 0 X 5 + 0 X 6 + 2 X 7 + 1 X 8 +
4 X 9 + 0 X 10 + 6 X 11 + 0 X 12 + 2 X 13 + 3 X 14 + 5 X 15 + 6
X 16 + 8 X 17 + 1 X 18 + 0 X 19 + 0 X 20 + 0 X 21 + 0 X 22
>/ 80

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```
BASIC SOLUTION  1
XB( 1 ) = X( 27 ) =  100
XB( 2 ) = X( 28 ) =  130
XB( 3 ) = X( 29 ) =  80
XB( 4 ) = X( 30 ) =  80
CURRENT VALUE OF THE OBJ. FUNC. IS -390000
BASIC SOLUTION  2
XB( 1 ) = X( 27 ) =  100
XB( 2 ) = X( 28 ) =  130
XB( 3 ) = X( 29 ) =  80
XB( 4 ) = X( 17 ) =  10
CURRENT VALUE OF THE OBJ. FUNC. IS -310000
BASIC SOLUTION  3
XB( 1 ) = X( 27 ) =  100
XB( 2 ) = X( 28 ) =  110
XB( 3 ) = X( 10 ) =  20
XB( 4 ) = X( 17 ) =  10
CURRENT VALUE OF THE OBJ. FUNC. IS -210000
BASIC SOLUTION  4
XB( 1 ) = X( 27 ) =  100
XB( 2 ) = X( 5 ) =  27.5
XB( 3 ) = X( 10 ) =  20
XB( 4 ) = X( 17 ) =  10
CURRENT VALUE OF THE OBJ. FUNC. IS -100000
BASIC SOLUTION  5
XB( 1 ) = X( 1 ) =  50
XB( 2 ) = X( 5 ) =  27.5
XB( 3 ) = X( 10 ) =  20
XB( 4 ) = X( 17 ) =  3.75
CURRENT VALUE OF THE OBJ. FUNC. IS  0
THE LAST BASIC FEASIBLE SOLUT. IS OPTIMAL
THE OPTIMAL VALUE OF THE OBJ. FUN. IS 0
TOTAL LOSSED TRIM = 0  INCH
```

WE SHOULD CUT :

==========================

[50] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 1

[27.5] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 5

[20] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 10

[3.75] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 17

CALCULATION TIME = 00:00:54

LINEAR PROGRAMMING

STANDARD WIDTH = 90 INCH

WE REQUIRED [30] ROLLS OF WIDTH ... [15] INCH

WE REQUIRED [20] ROLLS OF WIDTH ... [12] INCH

WE REQUIRED [50] ROLLS OF WIDTH ... [8] INCH

THE PROBLEM IS TO MINIMIZE :

0 X 1 + 3 X 2 + 7 X 3 + 6 X 4 + 6 X 5 + 1 X 6 + 5 X 7 + 0 X 8 + 4 X 9 + 3 X 10 + 3 X 11 + 6 X 12 + 2 X 13 + 6 X 14 + 2 X 15 + 6 X 16 + 2 X 17 + 6 X 18 + 2 X 19 + 2 X 20 + 15 X 21 + 12 X 22 + 8 X 23

S.T. :

6 X 1 + 5 X 2 + 5 X 3 + 4 X 4 + 4 X 5 + 3 X 6 + 3 X 7 + 2 X 8 + 2 X 9 + 1 X 10 + 1 X 11 + 0 X 12 + 0 X 13 + 0 X 14 + 0 X 15 + 0 X 16 + 0 X 17 + 0 X 18 + 0 X 19 + 4 X 20 + 0 X 21 + 0 X 22 + 0 X 23 >/ 30

0 X 1 + 1 X 2 + 0 X 3 + 2 X 4 + 0 X 5 + 3 X 6 + 0 X 7 + 5 X 8 + 0 X 9 + 6 X 10 + 0 X 11 + 7 X 12 + 6 X 13 + 5 X 14 + 4 X 15 + 3 X 16 + 2 X 17 + 1 X 18 + 0 X 19 + 1 X 20 + 0 X 21 + 0 X 22 + 0 X 23 >/ 20

0 X 1 + 0 X 2 + 1 X 3 + 0 X 4 + 3 X 5 + 1 X 6 + 5 X 7 + 0 X 8 + 7 X 9 + 0 X 10 + 9 X 11 + 0 X 12 + 2 X 13 + 3 X 14 + 5 X 15 + 6 X 16 + 8 X 17 + 9 X 18 + 11 X 19 + 2 X 20 + 0 X 21 + 0 X 22 + 0 X 23 >/ 50

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```
    BASIC SOLUTION  1
    XB( 1 ) = X( 27 ) =  30
    XB( 2 ) = X( 28 ) =  20
    XB( 3 ) = X( 29 ) =  50
CURRENT VALUE OF THE OBJ. FUNC. IS -100000
    BASIC SOLUTION  2
    XB( 1 ) = X( 27 ) =  30
    XB( 2 ) = X( 28 ) =  20
    XB( 3 ) = X( 19 ) =  4.545455
CURRENT VALUE OF THE OBJ. FUNC. IS -50009.09
    BASIC SOLUTION  3
    XB( 1 ) = X( 27 ) =  22
    XB( 2 ) = X( 8 ) =  4
    XB( 3 ) = X( 19 ) =  4.545455
CURRENT VALUE OF THE OBJ. FUNC. IS -22009.09
    BASIC SOLUTION  4
    XB( 1 ) = X( 1 ) =  3.666667
    XB( 2 ) = X( 8 ) =  4
    XB( 3 ) = X( 19 ) =  4.545455
CURRENT VALUE OF THE OBJ. FUNC. IS -9.090909
THE LAST BASIC FEASIBLE SOLUT. IS OPTIMAL
THE OPTIMAL VALUE OF THE OBJ. FUN. IS 9.090909
  TOTAL LOSSED TRIM = 9.090909  INCH

WE SHOULD CUT :
=========================

[ 3.666667 ] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 1

[ 4 ] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 8

[ 4.545455 ] LARGE ROLLS/SLICES USING THE BLADE POSITION OF COMBINATION NO. 19

        CALCULATION TIME = 00:00:38
```

LINEAR PROGRAMMING

STANDARD WIDTH = 100 INCH
WE REQUIRED [50] ROLLS OF WIDTH ... [50] INCH
WE REQUIRED [120] ROLLS OF WIDTH ... [25] INCH
WE REQUIRED [10] ROLLS OF WIDTH ... [22] INCH
WE REQUIRED [40] ROLLS OF WIDTH ... [8] INCH

THE PROBLEM IS TO MINIMIZE :
0 X 1 + 0 X 2 + 6 X 3 + 2 X 4 + 0 X 5 + 3 X 6 + 1 X 7 + 6 X 8 +
2 X 9 + 1 X 10 + 3 X 11 + 4 X 12 + 2 X 13 + 0 X 14 + 6 X 15 + 4
X 16 + 50 X 17 + 25 X 18 + 22 X 19 + 8 X 20

S.T. :
2 X 1 + 1 X 2 + 1 X 3 + 1 X 4 + 0 X 5 + 0 X 6 + 0 X 7 + 0 X 8 +
0 X 9 + 0 X 10 + 0 X 11 + 0 X 12 + 0 X 13 + 0 X 14 + 0 X 15 + 0
X 16 + 0 X 17 + 0 X 18 + 0 X 19 + 0 X 20 >/ 50

0 X 1 + 2 X 2 + 0 X 3 + 0 X 4 + 4 X 5 + 3 X 6 + 3 X 7 + 2 X 8 +
2 X 9 + 1 X 10 + 1 X 11 + 0 X 12 + 0 X 13 + 0 X 14 + 0 X 15 + 0
X 16 + 0 X 17 + 0 X 18 + 0 X 19 + 0 X 20 >/ 120

0 X 1 + 0 X 2 + 2 X 3 + 0 X 4 + 0 X 5 + 1 X 6 + 0 X 7 + 2 X 8 +
0 X 9 + 3 X 10 + 0 X 11 + 4 X 12 + 3 X 13 + 2 X 14 + 1 X 15 + 0
X 16 + 0 X 17 + 0 X 18 + 0 X 19 + 0 X 20 >/ 10

0 X 1 + 0 X 2 + 0 X 3 + 6 X 4 + 0 X 5 + 0 X 6 + 3 X 7 + 0 X 8 +
6 X 9 + 1 X 10 + 9 X 11 + 1 X 12 + 4 X 13 + 7 X 14 + 9 X 15 + 12
X 16 + 0 X 17 + 0 X 18 + 0 X 19 + 0 X 20 >/ 40

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```
    BASIC SOLUTION  1
    XB( 1 ) = X( 25 ) =  50
    XB( 2 ) = X( 26 ) =  120
    XB( 3 ) = X( 27 ) =  10
    XB( 4 ) = X( 28 ) =  40
CURRENT VALUE OF THE OBJ. FUNC. IS -220000
    BASIC SOLUTION  2
    XB( 1 ) = X( 25 ) =  50
    XB( 2 ) = X( 26 ) =  120
    XB( 3 ) = X( 27 ) =  10
    XB( 4 ) = X( 16 ) =  3.333333
CURRENT VALUE OF THE OBJ. FUNC. IS -150013.3
    BASIC SOLUTION  3
    XB( 1 ) = X( 25 ) =  50
    XB( 2 ) = X( 5 ) =  30
    XB( 3 ) = X( 27 ) =  10
    XB( 4 ) = X( 16 ) =  3.333333
CURRENT VALUE OF THE OBJ. FUNC. IS -60013.33
    BASIC SOLUTION  4
    XB( 1 ) = X( 25 ) =  50
    XB( 2 ) = X( 5 ) =  30
    XB( 3 ) = X( 12 ) =  2.5
    XB( 4 ) = X( 16 ) =  3.125
CURRENT VALUE OF THE OBJ. FUNC. IS -50022.5
    BASIC SOLUTION  5
    XB( 1 ) = X( 1 ) =  25
    XB( 2 ) = X( 5 ) =  30
    XB( 3 ) = X( 12 ) =  2.5
    XB( 4 ) = X( 16 ) =  3.125
CURRENT VALUE OF THE OBJ. FUNC. IS -22.5
    BASIC SOLUTION  6
    XB( 1 ) = X( 1 ) =  25
    XB( 2 ) = X( 5 ) =  30
    XB( 3 ) = X( 14 ) =  5
    XB( 4 ) = X( 16 ) =  .4166667
CURRENT VALUE OF THE OBJ. FUNC. IS -1.666668
    BASIC SOLUTION  7
    XB( 1 ) = X( 1 ) =  25
    XB( 2 ) = X( 5 ) =  30
    XB( 3 ) = X( 14 ) =  5.714287
    XB( 4 ) = X( 23 ) =  1.428573
CURRENT VALUE OF THE OBJ. FUNC. IS  0

OBJECT. FUNCT. IS NOT BOUNDED BY CONSTRS.

        CALCULATION TIME = 00:00:57
```

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vvvvvvvvvvv

ولذلك ، فقد تمت معالجة تلك المشكلتين فى هذا البحث وذلك بعمل (الجوريتم) يمكن تطبيقه فى مثل تلك الحالات وإستخدامه فى الحاسبات الالكترونية (أنظـــــر (2 - II) وكذلك تطبيق اساليب البرمجة الخطية الصحيحة nteger Programming وقد تم تطبيق وحل مجموعة من الأمثلة بمعطيات مختلفة وذلك بإستخدام اسلـــــوبى البرمجة الخطية والبرمجة الصحيحة وكذلك الوقت اللازم للحساب فى كل اسلـــــوب (أنظر الصفحات ١٧ ـ ٣٢).

والله ولى التوفيق ،

د. محمد يحيى عبد الرحمن

بسم الله الرحمن الرحيم

مشكلة فاقد التقطيع في الصناعة :ـ

مع ندرة المادة الخام وكثرة الطلب عليها وبالتالى ارتفاع سعرها ، أصبح من الضرورى بمكان استغلالها إقتصادياً الإستغلال الأمثل وهى إحدى المشكلات التى يعالجها علم بحوث العمليات .

ويتعرض هذا البحث لتطبيق الأساليب العلمية على إحدى اهم المشكلات التى تواجه كثيراً من الوحدات الإنتاجية الصناعية التى تعتمد فى تصنيع وتجميع منتجاتها على تقطيع المادة الخام بأطوال معينة وفقاً للمقاييس المطلوبة فى المنتج النهائى . فبعض الصناعات المعدنية والنسجية مثل الثلاجات ، الغاسالات ، الأثاث الملابس الجاهزة ، ... الخ ، تكون المادة الخام التى يتطلب تقطيعها فى صورة ألواح (كما فى الصناعات المعدنية) أو بكرات (كما فى الصناعات النسجية) . ومثل هذه الصناعات لن يكون إقتصادياً الا إذا كان حجم المنتج كبيراً نظراً لاستخدام عمالة مدربة وآلات تقطيع مكلفة مما يتطلب تجميع المادة الخام (الواح أو بكرات) وتقطيعها دفعة واحدة بأطوال معينة . وقد تتم عملية التقطيع بدون "فاقد" أو متبقى ولكن فى أغلب الأحيان قد يحدث العكس مما ينتج عنه فقد كمية من المادة الخام تعتمد على الاسلوب المتبع فى التقطيع .

ويهدف البحث إلى إستخدام بحوث العمليات والحاسبات الالكترونية فى حساب أنسب طريقة لتقطيع المادة الخام المستخدمة فى تلك الصناعات بحيث يكون يكون الفاقد من عملية التقطيع وكمية المادة الخام اللازمة أقل مايمكن .

وقد سبق أن عولجت تلك المشكلة نظرياً بإستخدام أساليب البرمجة الخطية ، ولكن هناك مشكلتان أساسيتان يجب التغلب عليهما لإستخدام هذا الاسلوب :ـ

١ ـ تحضير بدائل طرق التقطيع المختلفة والتى تمثل قيوداً اساسية لاسلوب البرمجة الخطية ،

٢ ـ قد تكون الحلول المثلى الناتجة كسرية أو غير صحيحة ، مما يتعارض مع اسلوب التصنيع وطبيعة المادة الخام .

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