International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 5, Issue 3, ISSN No. 2455-2143, Pages 513-517
Published Online July 2020 in IJEAST (http://www.ijeast.com)

USE OF LINEAR PROGRAMMING PROBLEM IN SMALL SCALE PAPER INDUSTRIES: A CASE STUDY OF COST MINIMIZATION STRATEGY FOR MILLENNIAL INDUSTRIALISTS

Dr. Abhijit Pandit
Amity Business School
Amity University, Kolkata, West Bengal, India

Abstract— **The main aim of the present research paper is to use linear programming problem in Small scale Industries for example paper, textiles, plastic and many more to help minimize the cost of manufacturing. There are the different models for solving the one dimensional, two dimensional, three dimensional and more models for stock cutting problem in the manufacturing industry. Linear programming (LP) is one of the simplest ways to perform optimization. It helps you solve some very complex optimization problems by making a few simplifying assumptions. As an analyst you are bound to come across applications and problems to be solved by Linear Programming.**

Keywords— **Operation research, linear programming, cutting stock, minimization**

I. INTRODUCTION

Most of small and large paper manufacturing companies are linear programming based (Dantzig (1998)). Cutting stock problem is the length problem of making the material available at a given cost the cost of a specified number of sizes of material to be cut from the specified stock by the customer at a minimum cost (Tanir et al (2016)).This difficulty persists when there is only one approximate solution. This problem can be solved by linear programming (Chvatal et al (1983)). Linear programming is described to overcome the difficulty of formulation(Gilmore et al (1961)).The large numbers of variables involved usually computes and solve the problem by linear programming techniques. In this study the pattern oriented approach is adopted to construct the cutting stock model(De Carvalho(2002)), a cutting pattern algorithm (Wang (1983)) is developed and solve by Lingo software (Krishnaraj et al (2015)) has been used. Linear programming (LP) model is containing by several possible patterns (Ogunranti et al (2016)). In industries such as paper, plastic food wrap, and textiles, products are initially manufactured in large economically manufactured sizes (Stier (1985)). These sizes are cut into smaller, more usable sizes because the product is held by the consumer (Paine et al (2012)).

II. PROPOSED ALGORITHM

A. Cutting paper Problem –

Bharat paper industry produces a large number of papers. The price of raw materials is an important part of the purchase of paper sheets (Gao et al (2003)). Currently, sheet paper is purchased in three different size widths: 72 inches, 48 inches and 36 inches. In the manufacturing process, eight different widths of paper sheets are required (inches): 60, 56, 42, 38, 34, 24, 15 and 10. All uses need the equal quality and thickness of paper sheet (Machelen et al (2016)). A constant problem is cutting paper waste (Denen et al (2003)). For example, single way to cut a 72-inch width of paper is to move it to a 38-inch width and two 15-inch widths. After this, 4-inch trim waste will have to be removed. The linear foot prices of width of three different raw materials are 31.05 kg for width 36, 41.4 kg for width 48 and 62.1 kg for "72" width. Ordinary arithmetic shows that the cost is three inches per inch. Widths for 36-inch, 48-inch and 72-inch widths respectively are Rs. is 69 kg / inch. The paper can be cut into any possible solution (Haessler (1992)). Potential cutting patterns are tabulated below to eliminate the width of the three raw materials. For example, pattern A1 is related to cutting a paper of 72 inches wide. There is 60" wide with, one 10" inches width and 2" left as trim waste. The sizes of different widths necessary in this plan period are:

Width(inches)	60	56	42	38	34	24	15	10
Number of sheet required	500	400	300	450	350	100	800	1000

The raw material achievements during this scheduling period are 150 kg of 72 inch paper and 100 kg each of 48 inch and 36

International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 5, Issue 3, ISSN No. 2455-2143, Pages 513-517
Published Online July 2020 in IJEAST (http://www.ijeast.com)

inch width. How many feet of each pattern should be cut to reduce costs while meeting different width requirements?

B. Total formulation of the problem –

Representations of A1, A2,…, E4 Show the number of widths to cut the equivalent pattern in the following table:

Raw Materials Cutting Patterns and Number of cuts required width									
Pattern (inches)	60	56	42	38	34	24	15	10	Waste
situation	**72" width Raw Material**								
AMT1	1	0	0	0	0	0	0	1	2
AMT2	0	1	0	0	0	0	1	0	1
AMT3	0	1	0	0	0	0	0	0	6
AMT4	0	0	1	0	0	1	0	0	6
AMT5	0	0	1	0	0	0	2	0	0
AMT6	0	0	1	0	0	0	1	0	5
AMT7	0	0	1	0	0	0	0	0	0
AMT8	0	0	0	1	1	0	0	0	0
AMT9	0	0	0	1	0	1	0	0	0
AMT10	0	0	0	1	0	0	2	0	4
AMT11	0	0	0	1	0	0	1	0	9
AMT12	0	0	0	1	0	0	0	0	4
AMT13	0	0	0	0	2	0	0	0	4
AMT14	0	0	0	0	1	1	0	0	4
AMT15	0	0	0	0	1	0	2	0	8
AMT16	0	0	0	0	1	0	1	0	3
AMT17	0	0	0	0	1	0	0	0	8
AMT18	0	0	0	0	0	3	0	0	0
AMT19	0	0	0	0	0	2	1	0	9
AMT20	0	0	0	0	0	2	0	0	4
AMT21	0	0	0	0	0	1	3	0	3
AMT22	0	0	0	0	0	1	2	0	8
AMT23	0	0	0	0	0	1	1	0	3
AMT24	0	0	0	0	0	1	0	0	8
AMT25	0	0	0	0	0	0	4	0	2
AMT26	0	0	0	0	0	0	3	0	7
AMT27	0	0	0	0	0	0	2	0	2
AMT28	0	0	0	0	0	0	1	0	7
AMT29	0	0	0	0	0	0	0	0	2
situation	**48" width Raw Material**								
AMT30	0	0	1	0	0	0	0	1	6
AMT31	0	0	0	1	0	0	1	1	0
AMT32	0	0	0	0	1	0	0	1	4
AMT33	0	0	0	0	0	2	0	0	0
AMT34	0	0	0	0	0	1	1	0	9
AMT35	0	0	0	0	0	1	0	2	4
AMT36	0	0	0	0	0	0	3	0	3
AMT37	0	0	0	0	0	0	2	1	8
AMT38	0	0	0	0	0	0	1	3	3
AMT39	0	0	0	0	0	0	0	4	8
situation	**48" width Raw Material**								
AMT40	0	0	0	0	1	0	0	0	2
AMT41	0	0	0	0	0	1	0	1	2
AMT42	0	0	0	0	0	0	2	0	6
AMT43	0	0	0	0	0	0	1	2	1
AMT44	0	0	0	0	0	0	0	3	6

For purposes, it is useful to define additionally:

T1 = width cut of 72" patterns,
T2 = width cut of 48"patterns,

T3 = width cut of 36" patterns,
W1 = inch of width waste from 72" patterns,
W2 = inch of width waste from 48" patterns,
W3 = inch of width waste from 36" patterns,
X1 = number of excess width cut of the 60"width,
X2 = number of excess width cut of the 56" width,
..
X8 = number of excess width cut of the 10" width.
Minimize the total inch waste cost.
For example: MIN = 0.8625 W1 + 0.8625W2 + 0.86W3;
This is especially possible when the cost per square inch is not the same for all raw material widths. A more reasonable objective is to reduce the total cost. i.e.
MIN = 0.621 * T1 + 0.414 * T2 + 0.3105 * T3;

III. Experiment and Result

MODEL:

SETS:

! Each raw material of the paper has a raw material width, the total is used,

Waste Total, Cost Per Unit, Waste Cost, and Supplies Available;

RM: RWDTH,T, W, C, WCOST, S;

! Each Finished good has a Width, units Required. eXtra produced;

FG: FWDTH, REQ, X;

PATTERN: USERM, WASTE, AMT;

PXF(PATTERN, FG): NUM;

ENDSETS

DATA:

! The raw material widths;

RM = R72 R48 R36;

RWDTH= 72 48 36;

C = .621 .414 .3105;

WCOST= .8625 .8625 .86;

S = 1600 10000 10000;

! The finished good widths;

FG = F60 F56 F42 F38 F34 F24 F15 F10;

FWDTH= 60 56 42 38 34 24 15 10;

REQ= 500 400 300 450 350 100 800 1000;

! Index of R.M. that each pattern uses;

USERM = 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2
3 3 3 3 3;

! How many of each F.G. are in each R.M. pattern;

NUM = 1 0 0 0 0 0 0 1
0 1 0 0 0 0 1 0
0 1 0 0 0 0 0 1
0 0 1 0 0 1 0 0
0 0 1 0 0 0 2 0
0 0 1 0 0 0 1 1
0 0 1 0 0 0 0 3
0 0 0 1 1 0 0 0
0 0 0 1 0 1 0 1
0 0 0 1 0 0 2 0
0 0 0 1 0 0 1 1
0 0 0 1 0 0 0 3
0 0 0 0 2 0 0 0
0 0 0 0 1 1 0 1
0 0 0 0 1 0 2 0
0 0 0 0 1 0 1 2
0 0 0 0 1 0 0 3
0 0 0 0 0 3 0 0
0 0 0 0 0 2 1 0
0 0 0 0 0 2 0 2
0 0 0 0 0 1 3 0
0 0 0 0 0 1 2 1
0 0 0 0 0 1 1 3

International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 5, Issue 3, ISSN No. 2455-2143, Pages 513-517
Published Online July 2020 in IJEAST (http://www.ijeast.com)

0 0 0 0 0 1 0 4
0 0 0 0 0 0 4 1
0 0 0 0 0 0 3 2
0 0 0 0 0 0 2 4
0 0 0 0 0 0 1 5
0 0 0 0 0 0 0 7
0 0 1 0 0 0 0 0
0 0 0 1 0 0 0 1
0 0 0 0 1 0 0 1
0 0 0 0 0 2 0 0
0 0 0 0 0 1 1 0
0 0 0 0 0 1 0 2
0 0 0 0 0 0 3 0
0 0 0 0 0 0 2 1
0 0 0 0 0 0 1 3
0 0 0 0 0 0 0 4
0 0 0 0 1 0 0 0
0 0 0 0 0 1 0 1
0 0 0 0 0 0 2 0
0 0 0 0 0 0 1 2
0 0 0 0 0 0 0 3;

ENDDATA

! Minimize cost of raw material used;

MIN = TCOST;

TCOST = @SUM(RM(I): C(I)*T(I));

! Compute total cost of waste;

TOTWASTE = @SUM(RM(I): WCOST(I)*W(I));

END

IV. CONCLUSION

If we reduce the cost of paper waste, and then we will get a different solution if we reduce the total cost of raw materials (Clelland et al(2000)). The two different solutions obtained under two different objectives are compared in the following table:

Patterns	Minimize total paper cost
AMT1	500
AMT2	400
AMT5	171.4286
AMT7	128.571
AMT8	350
AMT25	14.28571
AMT31	100.0000
AMT33	50.00000

Total waste 1232.143

Total paper cost 77521.93

T1 1564.286

T2 150.0000

T3 0

V. REFERENCE

[1] Chvatal, V., & Chvatal, V. (1983). Linear programming. Macmillan

[2] Clelland, I. J., Dean, T. J., & Douglas, T. J. (2000). Stepping towards sustainable business: An evaluation of waste minimization practices in US manufacturing. Interfaces, 30(3), (Pg 107-124)

[3] Dantzig, G. B. (1998). Linear programming and extensions (Vol. 48). Princeton university press

[4] De Carvalho, J. V. (2002). LP models for bin packing and cutting stock problems. European Journal of Operational Research, 141(2), (Pg 253-273)

[5] Denen, D. J., Yardley, C. D., Broehl, J. M., Hayes, R. J., Knittle, J. J., Linstedt, B. K., ... & Moody, J. R. (2003). U.S. Patent No. 6,592,067. Washington, DC: U.S. Patent and Trademark Office.

[6] Gao, Z., & Tang, L. (2003). A multi-objective model for purchasing of bulk raw materials of a large-scale integrated steel plant. International Journal of Production Economics, 83(3), (Pg 325-334).

[7] Gilmore PC, Gomory RE(1961). A Linear Programming Approach to the Cutting-Stock Problem. Oper Res.;9(Pg 849–859).

[8] Haessler, R. W. (1992). One-dimensional cutting stock problems and solution procedures. Mathematical and computer modelling, 16(1), (Pg 1-8).

[9] Krishnaraj, C., Jayakumar, A. A., & Shri, S. D. (2015). Solving Supply Chain Network Optimization Models Using LINGO. International Journal of Applied Engineering Research, 10(19), (Pg 14715-14718).

[10] Ogunranti GA, Oluleye AE(2016). Minimizing waste (off-cuts) using cutting stock model: The case of one dimensional cutting stock problem in wood working industry. J Ind Eng Manag. 9(Pg 834–59).

[11] Paine, F. A., & Paine, H. Y. (2012). A handbook of food packaging. Springer Science & Business Media.

[12] Stier, J. C. (1985). Implications of factor substitution, economies of scale, and technological change for the cost of production in the United States pulp and paper industry. Forest science, 31(4), (Pg 803-812).

[13] Tanir D, Ugurlu O, Guler A, Nuriyev U(2016). One-dimensional Cutting Stock Problem with Divisible Items.

[14] Van Mechelen, J. L. M., Maas, D. J. H. C., & Merbold, H. (2016, September). Paper sheet parameter determination using terahertz spectroscopy. In 2016 41st International Conference on Infrared, Millimeter, and Terahertz waves (IRMMW-THz) (Pg. 1-2). IEEE.

[15] Wang, P. Y. (1983). Two algorithms for constrained two-dimensional cutting stock problems. Operations research, 31(3),(Pg. 573-586).