APPLICATION OF OPERATIONS RESEARCH IN TEXTILE INDUSTRY

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Abstract: The profit or the loss incurred by a textile firm is heavily dependent on the way the firm utilizes the resources available to them. Hence this research paper focuses on the use of Operations Research techniques to create a strategy or mechanism that efficiently utilizes the resource available, taking a textile firm based in Surat as a case study. This firm produces two different types of sarees and the total cost of the material, indirect raw material cost (wastage, cutting etc.) and printing and packaging cost have been obtained from the company. The data collected is quantitative in nature and was provided the owner of the firm after interacting with him. The data obtained was mathematically modelled and was solved using the Microsoft Excel Solver. The main objective of the firm is to reduce the cost incurred and find an optimal product mix which increases the profitability of the firm. The observations of the research paper show that the firm could increase its profit from Rs 2,04,000 to 2,20,852 using the recommendations of the study.

Index Terms: **textile industry, linear programming, simplex, profit maximization.**

I. INTRODUCTION

The textile industry is primarily concerned with the design, production and distribution of yarn, cloth and clothing. The raw material may be natural, or synthetic using products of the chemical industry.

Since Surat is known for producing textiles, including silk, it is known as the textile hub of the nation or the Silk City of India. It is very famous for its cotton mills and Surat Zari Craft. Surat is the biggest center of MMF (man-made fibre) in India. It has a total of 381 dyeing and printing mills and 41,100 power loom units. There are over a hundred thousand units and mills in total. The overall annual turnover is around 5 billion rupees. There are over 800 cloth wholesalers in Surat. It is the largest manufacturer of clothes in India, and Surti dress material can be found in any state of India. Surat produces 9 million meters of fabric annually, which accounts for 60% of the total polyester cloth production in India. Now the city is focusing on increasing the exports of its textile. [1]

The textile industry in Surat is mainly engaged in the activities of yarn production, weaving, processing as well as embroidery.

Surat is well known for its synthetic products market. It is mainly engaged in the production and trading of synthetic textile products.

Nearly 30 million meters of raw fabric and 25 million meters of processed fabric are produced in Surat daily.[2]

The research paper aims to understand how operations research is used in the textile industry of Surat. For this, the data has been taken from a businessman in Surat who buys cloth from outside, carries out the printing and dying activity to the mills and then sells the final product(saree). The aim is to maximize the profit using **linear programming**.
Linear programming, mathematical modelling technique in which a linear function is maximized or minimized when subjected to various constraints. This technique has been useful for guiding quantitative decisions in business planning, in industrial engineering, and—to a lesser extent—in the social and physical sciences. [3]

II. LITERATURE REVIEW

There are multiple major concerns which are to be addressed when looking at the scenario in the textile industry. The primary concern for the company which is analyzed in the research paper is determining the optimal product mix which is to be produced by the firm [6][7]. The two research papers cited use Operations Research techniques to determine help determine an optimal mix for the firms the analyzed. The objective of the firm is to determine an optimal amount of the two types of the product which is to be produced which would guarantee the company the maximum possible profits [6]. The issue of formulating a solution is further complicated when you consider the different costs involved and the various limitations faced by the company [4]. The company itself faces no restrictions in the number of sarees they can supply in a month as a lot of the processes which are involved in the production of sarees are outsourced to different businesses in the city, but a major issue which arises is anticipating and predicting the demand that arises during different months in a year. The company has to finish the production of the sarees before the actual demand arises and the demand is very turbulent in this sector it continuously changes due to many external factors, but mainly due

to the shifting of the seasons. Correctly anticipating the demand which arises is also an integral part of the process as the company wants to maximize its profits by reducing the costs incurred by them when there is a surplus or shortage in the production of sarees for the month [5].

III. OBJECTIVE

The objective of the study is to understand how Operations Research can be used in the Textile Industry to maximize the profit by considering the various costs involved(constraints) in order to optimally utilize the resources for profit maximization.

IV. METHODOLOGY

The primary data collected is quantitative in nature and relied on interaction with the owner of the company. The information gathered is focused on two types of sarees. The direct raw material cost (cloth), indirect raw material cost (stationery), printing & packaging cost and total cost of both products is available. Using the gathered information, a **linear programming problem (LPP)** can be formed. This is because a firm in a competitive textile industry will aim to produce at the least possible cost by being efficient. An LPP model on data collected will allow an objective function, subject to constraints and non-negative condition to be formed. Furthermore, **Simplex method** of LPP can be performed on this particular data in order to identify the i**deal quantity** of the types of sarees produced by the company. The ideal quantity of both products is objective of the company; at each of the quantity of both sarees the total cost of both products is at minimum.

Simplex Method Algorithm (Maximization)
Step 1 - Formulate the Linear Programming Problem (Adding slack, surplus or artificial variables)
Step 2 – Construct an initial simplex table
Step 3 – Find the sacrifice and improvement rows
Step 4 – Apply the entry criteria
Step 5 – Apply the exit criteria
Step 6 – Construct a new simplex table
Step 7 – Repeat the steps until you find the optimum solution
[4]

V. DATA ANALYSIS AND RESULTS

Table 1: Direct Expenses of Sarees

	Type 1	Type 2
Cloth	Rs 11/meter	Rs 4/meter
Mill Printing charge	Rs 7.75/meter	Rs 9.5/meter
In Process Shortage	12%	15%
Meters per unit	6	6
Cost per unit	Rs 121	Rs 154

Table 2: Indirect Expenses

	Type 1 (Rs)	Type 2 (Rs)
Wastage	3	4
Cutting	1	1
Border Stitching	25	35

Steam Press	2	2
Photo	2	2
Packing	4	4

Table 3: Final Table

	Type 1	Type 2
Total Cost	Rs 158	Rs 202
Selling Price	Rs 170	Rs 220
Demand Units	8,000	4,000
Supply Units	9,500	5,000

In textile industry, there is no restriction or limits in the monthly supply. The firm can supply(produce) as many as units it wants and can even produce nothing since most of the processes are outsourced.
But since the production has to be completed before the demand arises, the businessman produces 9500 units of Type 1 and 5000 units of Type 2. The demand is quite volatile in this industry since it changes according to seasons and other external factors, the demand in the month when the data was collected was 8000 units of type 1 and 4000 units of type 2.

Constraint 1
Type 1 has in process shortage = 12%
Meters per unit = 6
Total cloth used in Type 1 Saree = (1 + 12%) * 6 = 6.72 meters
Cost of cloth in Type 1 = Rs 11/m
Total cost of cloth in Type 1 = 6.72 * 11 = Rs 73.92
Supply units = 9500
Therefore, monthly cost of cloth in Type 1 = 73.92 * 9500 = 702240

Type 2 has in process shortage = 15%
Meters per unit = 6
Total cloth used in Type 2 Saree = (1 + 15%) * 6 = 6.90 meters
Cost of cloth in Type 2 = Rs 14/m
Total cost of cloth in Type 2 = 6.90 * 14 = Rs 96.60
Supply units = 5000
Therefore, monthly cost of cloth in Type 2 = 96.60 * 5000 = 483000

Total cost of cloth in both products = 702240 + 483000=Rs 1185240

Constraint (Cloth)
73.92X1 + 96.60X2 = 1185240

Constraint 2
Type 1 has mill printing charge = Rs 7.75/meter
Meters per unit = 6
Printing charge in Type 1 = 7.75 * 6 = Rs 46.50
Supply units = 9500
Therefore, monthly cost of printing in Type 1 = 46.50 * 9500=Rs 441750

Type 2 has mill printing charge = Rs 9.50/meter
Meters per unit = 6
Printing charge in Type 2 = 9.50 * 6 = Rs 57
Supply units = 5000
Therefore, monthly cost of printing in Type 2 = 57 * 5000=Rs 285000

Total cost of printing in both products = 441750 + 285000 =Rs 726750

Constraint (Printing)
46.50X1 + 57X2 = 726750

Constraint 3
Total of additional costs per unit in Type 1:
Wastage per Saree Rs 3
Cutting charge Rs 1
Border stitching Rs 25
Steam press Rs 2
Photo Rs 2
Packing Rs 4
TOTAL Rs 37

Total of additional costs per unit in Type 2:
Wastage per Saree Rs 4
Cutting charge Rs 1
Border stitching Rs 35
Steam press Rs 2
Photo Rs 2
Packing Rs 4
TOTAL Rs 48

Type 1 = 37 * 9500 = 351500
Type 2 = 48 * 5000 = 240000
Total of indirect costs in both products = 351500 + 240000=Rs 591500

Constraint (Additional costs)
37X1 + 48X2 = Rs 591500

LPP Model

Objective function
The objective of the firm is to minimize the cost of both products.

Profit per unit of Type 1 Saree = Rs 12
Profit per unit of Type 2 Saree = Rs 18

MAX Z = 12X1 + 18X2

Subject to constraints

- **73.92X1 + 96.60X2 <= 1185240**
- **46.50X1 + 57X2 <= 726750**
- **37X1 + 48X2 <= 591500**

Data and constraints

Variable constraints	X	Y	Optimal solution	220852.2
Optimal Value	0	12269.57		
Max Z	12	18		
Subject to constraints				
73.92	96.6	1185240	<=	1185240
46.5	57	699365.2	<=	726750
37	48	588939.1	<=	591500

Answer Report

Microsoft Excel 16.0 Answer Report
Worksheet: [OR Solver.xlsx]Sheet2
Report Created: 04-10-2018 15:57:28
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.031 Seconds.
Iterations: 1 Subproblems: 0
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$E$1	Optimal sol	220852.1739	220852.1739

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$4	Optimal Value X	0	0	Contin
$C$4	Optimal Value Y	12269.56522	12269.56522	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$C$10 Y		1185240	$C$10<=$E$10	Binding	0
$C$11 Y		699365.2174	$C$11<=$E$11	Not Binding	27384.7826
$C$12 Y		588939.1304	$C$12<=$E$12	Not Binding	2560.86957

Sensitivity Report

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [OR Solver.xlsx]Sheet2
Report Created: 04-10-2018 15:57:29

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$4	Optimal Value X	0	-1.773913043	12	1.773913043	1E+30
$C$4	Optimal Value Y	12269.56522	0	18	1E+30	2.318181818

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$C$10	Y	1185240	0.186335404	1185240	5153.75	1185240
$C$11	Y	699365.2174	0	726750	1E+30	27384.78261
$C$12	Y	588939.1304	0	591500	1E+30	2560.869565

Limits Report

Microsoft Excel 16.0 Limits Report
Worksheet: [OR Solver.xlsx]Sheet2
Report Created: 04-10-2018 15:57:29

Cell	Objective Name	Value
$E$1	Optimal sol	220852.1739

Cell	Variable Name	Value	Lower Limit	Objective Result	Upper Limit	Objective Result
$B$4	Optimal Value X	0	0	220852.1739	0	220852.1739
$C$4	Optimal Value Y	12269.56522	0	0	12269.56522	220852.1739

The Simplex problem is solved using Excel Solver.

The optimum solution to maximize the profit is to only produce 12270 (rounded off) units of Type 2 saree. The businessman should not produce any units of Type 1 saree. When the businessman was producing 9500 units of Type 1 saree and 5000 units of Type 2 saree, the profit was 204000 Rs but whereas if he produces 12270 units of only Type 2 saree, the profit is 220852.

VI. REFERENCES

[1] https://en.wikipedia.org/wiki/Textile_industry, n.d.

[2] https://www.fibre2fashion.com/industry-article/2150/the-textile-industry-of-surat, n.d.

[3] https://www.britannica.com/science/linear-programming-mathematics, n.d.

[8]https://www.researchgate.net, n.d.

Works Cited

[4]*Application of Linear Programming Techniques to Determine the Type and Quantity of Textile Dyed Fabrics*, Gera Workie, Abebaw Bizunch and Senait Asmelash.

[5]*Case Study on Profit Planning of Textile Industry Using Linear Programming Approach,* Eshetie Kassegn, Dr. Ashish Thakur, Niguss Haregot, Aregawi Gebreyesus

[6]*The Optimization Problem of Product Mix and Linear Programming Applications: Case Study in the Apparel Industry*, Gera Workie Woubante.

[7]*Optimization of Woven Fabric Production in Textile Industry of PT. Argo Pantes Tangerang,* Dr. Ir. Raden Achmad Harianto